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MATHEMATICS.—*Spinors.*[1] OSWALD VEBLEN, The Institute for Advanced Study, Princeton.

The theory of spinors had its origin in the search for a suitable mathematical tool to use in the extension of the quantum theory to the field of relativity. The quantum mechanics in the form that was given to it by Schroedinger describes the motion of a particle by means of the concept of a wave. It is not, as people used to say, that a physicist thinks of an electron as a particle on Mondays, Wednesdays, and Fridays, and as a wave on Tuesdays, Thursdays and Saturdays, and on Sundays prays for a Messiah who will lead him back to the belief which he held on Mondays. The actual situation is quite different from that. He works with a mathematical theory which he visualizes for some purposes by means of the classical conception of a particle and for other purposes by means of the imagery of the wave theory. The wave that he works with is just a function which satisfies a partial differential equation of a certain type. The physicist believes that by applying a certain integration process to the solution of this partial differential equation he is able to express the probability that the particle which he thinks of shall be in a certain preassigned position with a certain preassigned velocity.

The whole thing is an attempt to find mathematical formulas and language for the discussion of phenomena which did not make sense in terms of the language and formulas which the physicists had been using before. Some people actually go so far as to say that we shall have to make real changes in our habits of thought and use of language. But I am referring to these deep and difficult questions only incidentally. I am concerned with something much more superficial.

[1] This is the fourth of the Joseph Henry Lectures of the Philosophical Society presented March 31, 1934, in honor of the first president of the Philosophical Society. This paper was prepared from stenographic notes taken at the time of the lecture. Received June 2, 1934.

The spinor theory grew out of the attempt to reconcile the wave mechanics with the relativity theory. The wave mechanics was at first developed so as to fit into the framework of the classical dynamics. On the other hand, the theory of relativity has taken such a firm hold of all branches of physics that everyone is convinced that a really sound theory must take it into account. Therefore, the problem was to find a relativistic formulation of the quantum theory.

Also there was experimental evidence indicating that from the partial point of view an electron should not be considered just as a mathematical point but rather as a thing which is capable of a rotary motion, or spin, at the same time that it has a motion of translation. The problem of bringing this concept into the theory of the electron turned out to be closely related to the problem of giving a relativistic formulation to the differential equations of the electron.

What looks like a very good solution of the problem was developed by Dirac, building upon previous work of Pauli and others. Dirac modified the Schroedinger differential equation not only by changing its form but by replacing it by a system of four equations with four unknown wave functions, ψ^1, ψ^2, ψ^3, ψ^4. These four functions were related among themselves in what seemed to be a very intricate manner, but they were evidently the components of a physical quantity of some sort.

When I speak of a physical quantity I am thinking of something which has components analogous to the components of a vector. When you take the three rectangular components of a velocity you recognize that you are taking components of something which has a physical existence. In the same way the quantities which appeared in the Dirac equation were evidently components of some sort of a physical object. But they behaved quite differently from the components of any previously known physical quantity and thus provided a puzzle for the mathematical physicist.

The problem was clearly formulated by the late Professor Ehrenfest. He said, in affect: We are familiar with such things as vectors which are the tools of classical physics. Since the advent of the relativity theory we have got acquainted with the theory of tensors and have been led to believe that any physical phenomena could be described by means of tensors. Now comes a new kind of a physical quantity which is not a tensor and yet has to be taken into account. It has something to do with a spinning electron. Let us call it a *spinor*. Then he called on the mathematicians to provide a theory of spinors, if possible, analogous to the theory of tensors.

The elements of such a theory were in fact already available in Dirac's own work and in the previous work of Darwin and Pauli. The Dirac equation had also been adequately discussed from the point of view of the underlying group theory by Weyl in his book on group theory and quantum mechanics, so that implicitly a good deal of the requisite theory was in existence. Nevertheless, so long as it was possible for a mathematical physicist of the order of magnitude of Ehrenfest to regard it as obscure there remained something of a problem.

Promptly in response to Ehrenfest's challenge, a formal theory of spinors was produced by van der Waerden. This was a theory of two-component spinors which was adequate to the Dirac equation in its original form. But here one has to say, as in so many other cases, that a fully satisfactory account of the subject was possible only after the original theory had been highly generalized. It was in fact so in this case. The original Dirac equation was relevant to the special relativity. The extension to general relativity was indicated first by Weyl and Fock and the system of mathematical equations thus determined has been studied by Schouten, Schroedinger, Einstein and Mayer, and other mathematical physicists. From these studies there has now emerged a clear conception of a class of physical objects which we call spinors and which can be precisely defined.

I shall try to state this definition. In doing so I propose to repeat a number of well-known elementary ideas leading up to the one step which introduces the definition. After this is done the whole matter may seem rather trivial, but it is nevertheless, true that after this foundation is laid the working out of the theory becomes a matter of technical detail.

We start with elementary geometry. How are the points in a room to be described? The first step in such a description is to give names to the points so as to distinguish them, and we agree to use numbers as names. A point will have a first name x, a second name y, and a third name z. The way which we all know for assigning these names is to let x be the distance of the point from the floor, y the distance from the wall at the front of the room, and z the distance from the side wall. That way of assigning the names is of course completely arbitrary. It could be done in some perfectly bizarre way so long as you satisfied the condition of giving different names to different points. A system of naming the points is what we call a coordinate system.

I have mentioned a particular way of naming the points only to emphasize the fact that the particular system we use for assigning these names is of no importance. We can, in fact, when we have one

way of naming them, get any number of other ways by the following device. Suppose you write down these three equations:

$$\begin{aligned} X &= x + y \\ Y &= x - y \\ Z &= z^2. \end{aligned} \tag{1}$$

If we substitute in these equations the numbers x, y, and z appearing in the name of this point, we get three other numbers (X, Y, Z) which gives us a new name for the point, and so we have a new coordinate system. These equations can be solved to give

$$\begin{aligned} x &= \tfrac{1}{2}(X + Y) \\ y &= \tfrac{1}{2}(X - Y) \\ z &= \sqrt{Z}. \end{aligned} \tag{2}$$

If we apply these equations to any point in the room and know the names X, Y, Z, we are able to get back the names x, y, z. We have a dictionary which translates one system of nomenclature for our points into another system of nomenclature. This dictionary is what we call a transformation of coordinates.

In general, a transformation of coordinates

$$(x, y, z) \rightarrow (X, Y, Z)$$

is defined if we replace the right-hand members of equations (1) by quite arbitrary functions subject only to the condition that (1) should be capable of being solved so as to obtain the inverse transformation

$$(X, Y, Z) \rightarrow (x, y, z)$$

analogous to (2). In all this we confine attention to points in the room, that is to say, to a limited portion of space. In practice we require that the functions used shall be amenable to the processes of analysis such as differentiation, etc., corresponding to the technique of the mathematician of the present epoch.

The essential point which I should like to stress in this consideration of coordinate systems and transformations of coordinates is that the coordinate system is something which we ourselves introduce. It is something in addition to the physical state that we are trying to describe and represents our point of view towards the natural phenomena which are under consideration. To be objective, we must somehow or other get away from this thing that we have introduced. In previous generations mathematicians and physicists used to play with the idea of doing without coordinates. The geometry of Euclid is an example in which coordinates were not used and the attempt was

made to reason directly with the physical objects we were talking about. Many will recall the time when it was regarded as important to do vector analysis without coordinates. This idea was based on the feeling that by so doing one was dealing with the natural object itself.

An equally good way of being free from the influence of the coordinates introduced is to use all coordinate systems. Using no coordinate system is, so to speak, the dual idea to using all possible coordinate systems. If you arrange your work in such a way that it applies no matter what the coordinate system is, then you have reached the ideal of dealing with the object itself. This point of view has become very common since the discussions which were brought about by the theory of relativity.

In dealing with physical problems much use is made of vectors. A vector is a special case of what we can call a physical object with components. The idea is something like this: Supposing that in a room we have at every point a tendency of a certain sort, no matter what sort, but a tendency in a definite direction with a definite magnitude. That tendency can be defined by associating with each point (x, y, z) three numbers V^1, V^2, V^3.

$$V^1(x, y, z) \quad V^2(x, y, z) \quad V^3(x, y, z).$$

They describe this tendency and they are the components of something that represents a physical state of affairs. If this physical object is a vector, then on making a transformation into a new coordinate system you will get functions

$$\overline{V}^1(\bar{x}, \bar{y}, \bar{z}) \quad \overline{V}^2(\bar{x}, \bar{y}, \bar{z}) \quad \overline{V}^3(\bar{x}, \bar{y}, \bar{z})$$

of the coordinates $\bar{x}, \bar{y}, \bar{z}$. When you measure this physical object in the new coordinate system, you will get the new set of quantities $\overline{V}^1, \overline{V}^2, \overline{V}^3$, and there will be definite formulas which tell you what these components in the new coordinate system are:

$$\overline{V}^1 = f^1(V^1, V^2, V^3) \quad \overline{V}^2 = f^2(V^1, V^2, V^3) \quad \overline{V}^3 = f^3(V^1, V^2, V^3).$$

You will have three formulas of this sort which express the new components as functions of the old ones. There is no need of my mentioning what these formulas are in detail, for in talking about a subject which is full of formulas, we should be hopelessly lost if we got tangled up with particular formulas. The essential point which I want to bring out is that when you change to a new coordinate system you get a new set of components and in every coordinate system there is a set of components for the physical object. If the law which tells you the

new components in terms of the old components is of a particularly simple sort, then your physical object is a vector. There are lots of other physical objects. For example there are physical objects with 9 components that you could call $T_{1\,1}$, $T_{1\,2}$, $T_{1\,3}$, etc., using two indices. Then if you have a certain formula connecting the components in one coordinate system with those in another, the thing you are talking about is a tensor of the second order. The essential things about a tensor are that it is a physical object with components, and that the components are uniquely determined when the coordinate system is given in terms of which the components are described. I am intentionally leaving this statement in a thoroughly abstract form.

When we come to the theory of relativity we must pass from the three-dimensional space of points to the four-dimensional world of events. This is a story which you have probably heard many times. If you want to describe the events which take place in this room, you have to give not merely x, y, and z which tell you *where*, but also t, which tells you *when*, for each event. The essential point is that the events we talk about are things which are capable of being named by means of four names, the four names being numbers. This can be expressed by saying that the events constitute a four-dimensional world or space-time.

Let us transfer what we have just been saying about coordinate systems from the world of points over to the world of events. We make the same remark that we made before. The essential thing about a coordinate system for events is not any particular way of setting up the coordinate system but is the fact that the coordinate system assigns distinct names to different events.

In order to make an objective description of the world of events, we deal with the totality of coordinate systems. We keep free from any particular point of view and so talk about all coordinate systems at once. For this purpose we have a complete theory of transformations of coordinates and a theory of vectors and tensors. A tensor is a physical object such that with every event we are able to associate a set of numbers called its components when we have before us a given coordinate system. If we change to a new coordinate system we get a new set of components of the same physical object.

Thus in the general relativity theory itself we have a set of 16 functions

$$g_{11}(x^1x^2x^3x^4) \quad g_{12}(x^1x^2x^3x^4), \cdots, g_{44}(x^1x^2x^3x^4).$$

These functions of the coordinates are the components of a physical

object called the fundamental gravitational tensor. They satisfy a system of partial differential equations, and the theory of these equations is the relativity theory. The general conception is this: We assume that a given body of physical phenomena is representable by a physical object with components of a certain type, and the theory of these phenomena is contained in the set of differential equations which the components satisfy. This, without any formalism, is the basic mathematical idea which appears in the relativity theory.

Continuing in that theory, it turns out that there are certain other kinds of geometrical objects which have to be considered. The ones which appear first are the electromagnetic potentials. Again there are four components

$$\phi_1, \phi_2, \phi_3, \phi_4$$

which are functions of the coordinates. But, as physicists know, when you give the coordinate system the electromagnetic potentials are not fully determined. You can take another function $f(x^1, x^2, x^3, x^4)$ and add the four derivatives of this function to the components, obtaining

$$\phi_1 + \frac{\delta f}{\delta x^1}, \quad \phi_2 + \frac{\delta f}{\delta x^2}, \quad \phi_3 + \frac{\delta f}{\delta x^3}, \quad \phi_4 + \frac{\delta f}{\delta x^4}$$

without changing the physical significance of these potentials.

Let us try to say what is essential in this without using technical language. It ought to be clear even to those who do not know what these differentiation symbols mean. When we specify a definite coordinate system we have not only one set of four functions which appear as the components of our physical object, but we have a whole class of other sets of components. The physical object in question is of an essentially different kind from those which we have previously been talking about. Its components are not fully determined when the coordinate system is given; something in addition has to be specified before the components are known. This additional something which we have to specify we will call a gauge frame.

I might also try to put it in the following way: We previously said that when we introduce a coordinate system we put something into the phenomena of nature, and before we can be talking about nature itself we have to get free of the coordinate system which we put in. When we talk about electromagnetic potentials, we put something else in, namely, the gauge frame, which has to be specified before we can specify the particular set of components which we are talking about.

So our theory has to be such that we make not only transformations of coordinates but transformations of gauge, and we have to formulate our laws of physical phenomena in a manner which is unaltered not only by changes of coordinate system but also by changes of gauge. Physicists have heard a good deal about that under the heading of gauge invariance. The underlying idea is just as before: In trying to describe nature we have introduced not only coordinate systems, but also another extraneous element called the gauge frame. In addition to the theory of coordinate transformations, there is a theory of gauge transformations which has to be recognized in order to free our theory of physical phenomena from this element which we introduced in our view of nature.

The theory of spinors requires another step in this direction. A spinor is a physical object with components. The number of components is a power of four. In a particular case a spinor may have four components ψ_1, ψ_2, ψ_3, ψ_4. The components are functions of the coordinates just as the ϕ's and g's were, but when the coordinate system and the gauge frame are given, the components of the spinor are not fully determined. You can take a new set of components $\bar{\psi}_1$, $\bar{\psi}_2$, $\bar{\psi}_3$, $\bar{\psi}_4$, which will serve equally well as a set of components of this spinor. The new components are given by means of linear formulas in terms of the old components,

$$\bar{\psi}_1 = T_1^1\psi_1 + T_1^2\psi_2 + T_1^3\psi_3 + T_1^4\psi_4;$$

and three other formulas which look like this one. The coefficients T are arbitrary functions. A linear transformation of this sort is called a spin transformation.

When you have given your coordinates and your gauge, there is still something free, which we will call the spin frame, and we are unable to describe our physical object until the spin frame is fixed. In other words, we have got to state everything that we say about a spinor so that it will be true no matter what spin transformation is applied to the components. A spin transformation is very analogous to a coordinate transformation, but it takes place completely independently of the coordinate transformation.

This is the simplest example of a spinor. There are spinors with 16 components or in general with 4_k components and you will have linear formulas which give you the other possible sets of components in the same coordinate system.

I have not yet mentioned one of the important facts about spinors

which give them their significance. Their components are not ordinary numbers. They are complex numbers of the form

$$a + \sqrt{-1}\, b$$

where a and b are real numbers. In this respect they are like other physical objects which appear in quantum theory. There have been cases in physics before where the complex numbers were used as a convenient device, but here they come in an essential way.

The additional degrees of complication which appear in the definition of a spinor correspond to the nature of the physical problem which it is designed to meet. Ordinary vectors and tensors would be well enough adapted to tell where an electron is, in what direction it is going, and what its angular momentum is. But the quantum theoretic problem states the problem differently. It does not ask directly what these quantities are but rather, what are the probabilities that these quantities shall take on preassigned values. To meet this requirement, it is not the components of the spinors themselves which are interpreted in terms of physical measurements, but certain combinations of these components with their complex conjugates. These combinations of components of spinors are components of ordinary tensors and are interpreted as probabilities that the electron will be in a certain place moving in a certain way.

Let us now repeat the description of a spinor in a few words. A spinor is a physical object which has components which are complex functions of the coordinates. The number of components is a power of four. A set of components is fixed only after (1) the coordinate system, (2) the gauge-frame and (3) the spin frame, are fixed. Whenever (1), (2), or (3) are changed, the components are replaced by linear combinations of themselves according to definite rules.

Suppose that you have spinors with 16 components with two indices, X_{AB}, and supposing that these spinors satisfy the condition that

$$X_{AB} = -X_{BA}, \tag{3}$$

so that they are antisymmetric. Then the mathematicians will recognize that connected with them there is a quadratic expression

$$X_{12}X_{34} + X_{13}X_{42} + X_{14}X_{23} = 0. \tag{4}$$

Those spinors which satisfy this relation have peculiar properties, and it is this quadratic relation which puts the spinors into connection with the fundamental tensor of the relativity theory, because the g's

that we have in relativity are also the coefficients of a quadratic expression.

If you are going to describe some particular physical phenomena such as those described by the relativistic theory of the spinning electron, you must pick out one or more particular spinors which embody the physical phenomena in question. It turns out in this special case that you can pick spinors which set up a suitable relationship between the quadratic equation (4) above and the fundamental quadratic form which appears in the relativity theory. The general theory of spinors is the theory of all possible physical quantities of a certain sort. The theory of the electron is the theory of certain particular spinors which describe this electron.

BOTANY.—*New species of* Aulacolepis *and other grasses.*[1] A. S. HITCHCOCK, Bureau of Plant Industry.

The genus *Aulacolepis* was established by Hackel who based it upon *Deyeuxia treutleri* Stapf (*Milium treutleri* Kuntze). It is allied to *Agrostis* and to *Calamagrostis* (Sect. *Deyeuxia*), differing from the former in the comparatively large firm lemma and from most of the species in the prolonged rachilla, and from *Calamagrostis* in the absence of the long callus hairs and the dorsal awn. Hackel described a second species, *A. japonica*, from Japan, and recently a third species, *A. milioides* (Honda) Ohwi, has been described from the same country. *Aniselytron agrostoides* Merr., of the Philippines, described as differing from *Aulacolepis* chiefly in the obsolete or much reduced first glume may also belong to that genus. In the present paper two species are added to this interesting genus, one from Borneo, the other from Tonkin.

Aulacolepis clemensae Hitchc., sp. nov.

Perennis (?); culmi ascendentes, glabri, circa 60 cm. alti; ligula firma, truncata, 1 mm. longa; laminae planae, 8–15 cm. longae, 5–8 mm. latae; panicula laxa, 8–18 cm. longa, ramis ascendentibus, 3–5 cm. longis; glumae inaequales, acuminatae, prima 1-nervia, 2 mm. longa, secunda 3-nervia, 2.5 mm. longa; lemma quam glumae firmius, lanceolatum, scaberulum, 3 mm. longum; processus rachillae tenuis, 0.5 mm. longus.

Apparently perennial; culms ascending, glabrous, several-noded, about 60 cm. tall; sheaths glabrous; ligule firm, truncate, 1 mm. long; blades flat, slightly scaberulous beneath, puberulent on the upper surface, scaberulous on the margins, narrowed toward the base, acuminate, 8 to 15 cm. long, 5 to 8 mm. wide at the middle; panicle rather loose and lax, short exserted or inclosed at base in the uppermost sheath, 8–18 cm. long, the axis angled,

[1] Received April 17, 1934.

nearly glabrous, the branches slender, flexuous, scabrous, somewhat distant, ascending, 3 to 5 cm. long, the branchlets few-flowered; glumes unequal, acuminate, keeled, slightly scaberulous on the keels, the first 1-nerved, 2 mm. long, the second 3-nerved, 2.5 mm. long; lemma lanceolate, compressed, firmer than the glumes, scaberulous over the surface, 5-nerved, the lateral nerves near the margin, the intermediate nerves faint, 3 mm. long, minutely pubescent at base; palea about as long as the lemma but narrower, acuminate, minutely pubescent, inclosed within the lemma, the two keels compressed together; rachilla prolonged between the keels of the palea as a minute bristle 0.5 mm. long.

Type in the U. S. National Herbarium, no. 1,538,647, collected on the boulder margin of the Masilau River, Mount Kinabalu, British North Borneo, alt. about 3000 meters, December 26, 1933, by Mrs. M. S. Clemens (no. 34448).

Aulacolepis petelotii Hitchc., sp. nov.

Perennis (?); culmi caespitosi, erecti, glabri, 25–40 cm. alti; ligula membranacea, 2 mm. longa; laminae erectae, planae, scaberulae, 4–8 cm. longae, 1–3 mm. latae; panicula angusta, laxa, pallida, 6–10 cm. longa; glumae aequales, compressae, 2 mm. longae; lemma circa 2 mm. longum, chartaceo-membranaceum, lanceolatum, 5-nervium, sub apice minute aristatum, callo breviter piloso; rachilla ultra florem in stipitem brevissimum nudum producta; palea angusta, 1.5 mm. longa; stamina 3, antheris 0.5 mm. longis.

Apparently perennial, culms many in a rather loose tuft, erect, or the outer ones somewhat geniculate at base, glabrous, about 3-noded, 25–40 cm. tall; sheaths glabrous; ligule membranaceous, ovate, dentate or somewhat lacerate, about 2 mm. long; blades erect or ascending flat, scaberulous beneath, scaberulous-puberulent on the upper surface, striate-nerved, 4–8 cm. long, 1–3 mm. wide; panicles narrow, loose, pale, whitish or greenish, more or less inclosed in the upper sheaths, 6–10 cm. long, the axis scabrous, the branches scabrous, slender, naked below, branching, the spikelets clustered near the ends of the branchlets, the ultimate pedicels 1 mm. long or less; glumes equal, compressed, narrow, rather abruptly acute, minutely roughened on and near the keel, about 2 mm. long; lemma slightly longer and less compressed than the glumes, chartaceo-membranaceous, lanceolate, 5-nerved, the midnerve projecting just below the tip as a very short awn, the callus short-pilose, the rachilla prolonged behind the palea as a very minute naked bristle; palea narrow about three-fourths as long as the lemma; stamens 3, the anthers 0.5 mm. long.

Type, in the U. S. National Herbarium, no. 1,538,648, collected along a road near Chapu, Tonkin, alt. about 1900 meters, August, 1933, by A. Petelot (no. 4743).

Muhlenbergia lindheimeri Hitchc., sp. nov.

Perennis; culmi erecti, 1–1.5 m. alti, vaginis inferioribus imbricatis compressis; ligula elongata; laminae elongatae, planae, interdum plicatae, 3 mm. latae, scaberulae vel glabrae; panicula angusta, pallida, densiuscula, erecta, 20–40 cm. longa, ramis appressis 2–5 cm. longis; spiculae 2.5–3 mm. longae; glumae aequales, acutae vel obtusiusculae, scabro-puberulentae vel glabriusculae; lemma 2.5–3 mm. longum, glabrum vel obscure pubescens muticum, raro aristatum, arista 1–3 mm. longa.

Perennial; culms erect, 1 to 1.5 meters tall, the numerous overlapping lower sheaths keeled; ligule rather thin, elongate, mostly hidden in the folded base of the blade, blades elongate, firm, flat or usually folded, about 3 mm. wide, scaberulous or glabrous; panicle narrow, pale, somewhat loose, erect, 20 to 40 cm. long, the branches ascending or appressed; spikelets 2.5 to 3 mm. long; glumes equal, acute to rather obtuse, scabrous-puberulent to nearly smooth; lemma usually a little shorter than the glumes, 3-nerved, glabrous or obscurely pubescent, awnless or rarely with an awn 1 to 3 mm. long.

Type in the U. S. National Herbarium, no. 998,949, collected in Texas in 1847 by F. Lindheimer (no. 725).

Other specimens, all from Texas, are: *Berlandier* 1870; *Carter* 19; *Lindheimer* 1255 (Distr. Mo. Bot. Gard.); *E. J. Palmer* 10859, 11004; *Reverchon* 1610; *Silveus* 11, 354, 355; *Tharp* 70, 3076.

This species has been confused with the closely related *M. fournieriana* Hitchc. (*Epicampes berlandieri* Fourn., not *Muhlenbergia berlandieri* Trin.) which is confined to Mexico.

About 1902 there appeared in Queensland, Australia, a species of *Phalaris* which gave promise of being a valuable forage grass. About 1907 it was distributed from the Toowoomba Botanic Gardens, Queensland, and was first grown in the United States at the California Experiment Station and later at other stations. Burbank has distributed the grass as Peruvian winter grass. The species was named by Hackel *Phalaris stenoptera*. It differs from *P. tuberosa* L. only in having a loosely branching rhizomatous base, the lower internodes little or not at all swollen (*P. tuberosa* has a distinctly tuberous base). Agriculturally it seems sufficiently distinct to warrant recognition as a variety.

Phalaris tuberosa var. **stenoptera** (Hack.) Hitchc.

Phalaris stenoptera Hack. Repert. Sp. Nov. Fedde 5: 333. 1908.

Stipa coronata var. **depauperata** (Jones) Hitchc.

Stipa parishii var. *depauperata* Jones, Contr. West. Bot. 14: 11. 1912. Detroit, Utah, *Jones* in 1891.

Stipa parishii Vasey, Bot. Gaz. 7: 33. 1882. San Bernardino Mts., *Parish Bros.* 1079.

Stipa coronata parishii Hitchc. Contr. U. S. Nat. Herb. 24: 227. 1925.

This change is necessary under the International Rules which require that the earliest legitimate name in its own category be retained.

Manisuris altissima (Poir) Hitchc.

Rottboellia altissima Poir. Voy. Barb. 2: 105. 1789.

Rottboellia fasciculata Lam. Tabl. Encycl. 1: 204. 1791.

Hemarthria altissima Stapf & Hubbard, Kew Bull. Misc. Inf. 1934: 109. 1934.

PALEOBOTANY.—*The supposed fossil ear of maize from Cuzco, Peru.*[1] ROLAND W. BROWN, U. S. Geological Survey. (Communicated by JOHN B. REESIDE JR.)

Since 1919 the attention of botanists, interested in the origin and evolution of Indian corn, has from time to time been directed to an object (Fig. 5) described by the late Dr. F. H. Knowlton[2] as a fossil ear of maize. Reference to several papers[3] in which the object is further photographed, described, and compared with varieties of maize, shows that the designation of it as a fossil by Knowlton has at least been tentatively accepted as true. It is my purpose now to produce conclusive evidence that this object is not a fossil, and thus I hope to correct as gently and as far as possible an unfortunate paleontologic mistake.

The known historical facts about this object are meager. It was obtained in 1914 by Dr. W. F. Parks, of St. Louis, Mo., from a curio dealer in Cuzco, Peru. Dr. Parks transmitted it to Dr. Walter Hough, Curator of Ethnology in the U. S. National Museum, who gave it to Dr. Knowlton for identification. Knowlton passed it around among his botanical friends, from one of whom, G. N. Collins, of the U. S. Department of Agriculture, he received the helpful suggestion that externally it had a striking resemblance to a variety of Peruvian maize. Knowlton thereupon described the specimen as a supposed new fossil species of maize, calling it *Zea antiqua*, not because he could distinguish it from the living variety it resembled, but for the sake of independent reference.

That Knowlton unreservedly regarded this object as a fossil is implied in his statement concerning its age. He says: "It is of course extremely unfortunate that nothing is known as to the condition under which this specimen was found. If this were known it might be possible to fix its age with a reasonable degree of certainty. As it stands, however, there is little but *the the fact of its thorough fossilization*[4] to base an opinion on, and from this I venture the tentative suggestion that it seems hardly likely to be younger than at least several

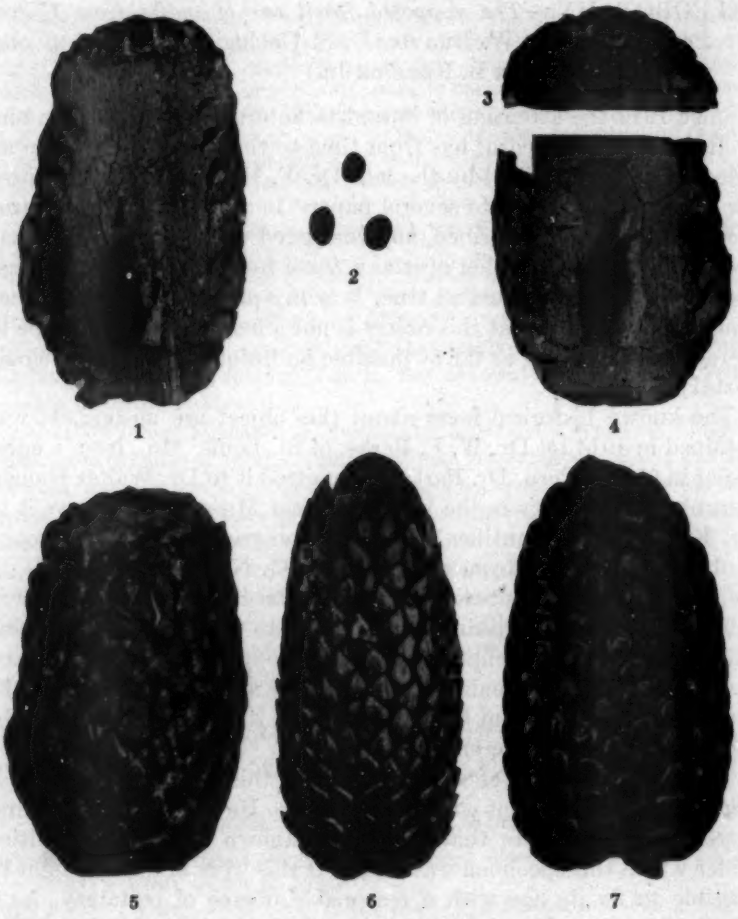
[1] Published by permission of the Director, U. S. Geological Survey. Received Feb. 19, 1934.

[2] KNOWLTON, F. H. *Description of a supposed new fossil species of maize from Peru.* This JOURNAL 9: 134–136. 1919.

[3] COLLINS, G. N. *A fossil ear of maize.* Jour. Heredity 10: 170–172. 1919. *An ear of prehistoric maize that resembles the fossil form, Zea* antiqua. Jour. Heredity 14: 61–64. 1923.

KEMPTON, J. H. *Maize, the plant-breeding achievement of the American Indian* Smithsonian Sci. Ser., 11: 319–349. 1931.

[4] Italics mine.



Figs. 1, 4. Lengthwise sections through middle of specimen shown in Fig. 5. Walls of cavity in Fig. 4 show tool marks. Fig. 2. Pellets found in cavity at base of specimen. Fig. 3. Transverse section, a top view of specimen shown in Fig. 4. Fig. 5. The supposed fossil ear of maize before cutting. Fig. 6. Ear of maize from a pre-Inca grave at Arica, on the coast of Chile. Found in 1913. Fig. 7. Ear of maize grown by Peruvian Indians in 1925. All figures natural size. Figures 5, 6, 7, by courtesy of J. H. Kempton, Bureau of Plant Industry, U. S. Department of Agriculture.

thousand years." It is most regrettable that Knowlton did not have the object cut, so that he could determine its petrographic nature. That he did not have it cut seems inexplicable, except on the hypothesis that he considered the specimen as the only one of its kind known and therefore hesitated to damage it by sectioning.

The first fermentation past, this matter aged quietly while the type specimen reposed in the paleobotanical collections of the National Museum. Interest in the supposed fossil, however, was revived recently when Dr. R. F. Griggs, Professor of Botany at George Washington University, and one of his students, F. S. MacNeil, of the U. S. Geological Survey, inquired about it. Suspecting from the time I first saw it in 1929 that this object was not a real fossil, I now determined to test my suspicions by having the specimen sectioned. My assistant, K. J. Murata, cut a transverse section (Fig. 3) near the top, a radial lengthwise section (Figs. 1, 4), and prepared a thin section for microscopic examination. These sections show conclusively that the object, instead of being a fossil, is a very cleverly hand-made, low-fired, clay copy of an ear of Peruvian maize, comparable perhaps to the ears shown in Figures 6 and 7.

Looking at the fresh faces made by the cuts one finds these characters: The color is a dull, dirty brown, tinged with red. The matrix can be scratched easily with a knife. To the naked eye it appears homogeneous, except for scattered light-colored grains of quartz and limestone. On the transverse section the supposed cob showing the insertion of the separate kernels is clearly defined. The cob is round-angular, with a smooth margin between the kernels. This fact would be sufficient in itself to discredit the object as a fossil, for if it were a fossil the surface of the cob would be rough, showing contiguous shallow pits or scars where the kernels were attached. The shape, inner surface, and angle of attachment of these kernels suggest that the kernels were separately fashioned. They are of the same material as the core.

The most striking feature on the radial lengthwise faces is the conical cavity near the base. The walls in the upper portion of the cavity show a few deep, oblique indentations, which are clearly the marks of a blunt-edged tool used in shaping the cavity. Three small, smooth, oval pellets (Fig. 2) that before the sectioning caused a faint rattle when the specimen was shaken, were found in the cavity. The significance of the cavity, the pellets, and the rattle, is as conjectural as that of the specimen itself; but other objects with rattles are said to be not uncommon among the artifacts of Central American and South American Indians.

Knowlton observed the fact that the matrix lacks the delicate cellular structure displayed, for example, by many petrified woods. He, however, did not state his theory as to how the object became fossilized but said that the matrix is "a closely cemented, fine-grained

siliceous sand." Actually, microscopic examination of the thin section by Dr. C. S. Ross, of the U. S. Geological Survey, and Miss Anna Shepard, of the Laboratory of Anthropology, Santa Fe, N. Mex., showed that the matrix is a partially baked clay containing a small amount of coarse-grained material. The latter includes free quartz grains, a little feldspar, hornblende, mica, garnet, and zircon, a considerable amount of fine-grained, iron-stained sandstone, limestone, and calcite, and a few fragments of what apparently are reworked bits of clay previously used for pottery. The object was baked at only a moderate temperature, as is demonstrated by the fact that, although the clay has lost its plasticity, the carbon dioxide has not been driven from the limestone and calcite.

I had hoped that a minute examination of this object would show the personal signature of its maker, but I am not convinced that the obscure and delicate striations present in a few spots actually are baked fingerprints. Nevertheless, the object is so clever a copy of an original ear of Peruvian maize that the maker must be credited with having been an artist of superior skill. The questions as to who made this object and when, where, and why it was made must now be referred to the ethnologists and archeologists. The answers may throw some light on the interesting problems concerning the origin and early cultivation of maize.

This episode of a supposed ear of fossil maize may be closed fittingly with the pointing of a moral, particularly pertinent to paleontologists: Be not deceived by external appearances.

ZOOLOGY.—*Affinities of the Brachyuran fauna of the Gulf of California.*[1] STEVE A. GLASSELL, San Diego Society of Natural History. (Communicated by WALDO L. SCHMITT.)

The author having obtained numerous specimens of Brachyura from the Gulf of California during two collecting trips, and having studied the results of other collectors in that region, believes that a brief summary of the fauna of that region in comparison with that of the regions to the north and south would be of general interest to carcinologists.

The interesting relationship of the Panamian fauna to that of the Gulf of Mexico need not be considered here since this has been discussed by Walter Faxon,[2] but the distribution of tropical (Panamian)

[1] Received December 26, 1933.
[2] Mem. Mus. Comp. Zool. Harvard College, 18: 231–50. 1895.

Brachyura in the Gulf of California has not been heretofore studied to any extent, and it seems probable that an infusion of southern forms into the Gulf of California has had much to do in making up the character of the rich fauna which is now known to exist in the latter region.

In general it is in the Gulf of California that the tropical species make their most northerly advance on the Pacific coast of North America, although of course some few species have their most northern limits far north of the Gulf. For these northern species it may be difficult to determine whether they originated in northern or southern latitudes. Even a study of their Bathymetric zones does not clarify the situation. To cite a single instance. *Pinnixa affinis* Rathbun was dredged in the Bay of Panama by the *Albatross* in 26 fathoms, March 30, 1888. On October 20, 1933, a specimen was dredged off Newport Bay, California, in 20 fathoms. The inference must be that there is a connecting link between these wide flung stations, that this little crab must be included in the fauna of the Gulf of California, because the Gulf is bracketed between the discovery station and this latest find. Yet to which fauna shall it be allocated? At present this is a matter of personal opinion.

Arbitrary boundaries are taken so as to form a base on which to work. This will exclude some tropical and northern forms from this fauna, which will no doubt be included in the light of future research. I take as the boundaries, for purposes of this paper, those which admit of fewer occasional or accidental intrusions of species into the area bounded by, and including the waters impounded to the north of a line drawn from Cabo San Lucas, in Lower California, to the Port of Mazatlan, in the State of Sinaloa, Mexico, and also the fauna reported and found on the West Coast of Lower California, at Magdalena Bay. In this delimitation of range no attempt is being made to establish or admit of faunal barriers.

Also we will only consider species of Brachyuran Crustacea of the three major groups, namely, the Cancroid or Cyclometopous crabs, the Grapsoid or Catometopous crabs, and the Spider crabs or Oxyrhyncha. The total number of species of the three groups, found within these boundaries is 197, a very large list when we consider that we are dealing with just a part of the marine decapods. For example Dr. Waldo L. Schmitt[3] lists only 181 marine decapods as known to occur within the 100 fathom line off the coast of California.

[3] The Marine Decapod Crustacea of California. Univ. of Calif., vol. 23: 281. 1921.

A summary of the total number of species of the three groups is as follows:

Cancroid crabs reported in the Gulf of California,	77	species.
Grapsoid " " " " " " "	54	"
Spider " " " " " " "	66	"
Total of all species reported	197	

The intrusion of Panamian species into the Gulf of California, number 96 or 48 per cent of all the species reported in these writers. They are divided as follows:

Cancroid crabs	39	species, or	50+	per	cent
Grapsoid "	25	" "	46+	"	"
Spider "	32	" "	48+	"	"
Total of three groups	96	species, or	48+	per	cent

The above percentages represent the percent which the Panamian species bear to the total number of species in each family group. Further intensive study and collecting will no doubt show that the Anomuran tribe and the remaining families of the Brachyuran tribe will bear a like relationship to the Panamian fauna.

Another interesting summation is a table showing the number and percentages of species that are indigenous to the Gulf of California.

Cancroid crabs	27	species, or	35+	per	cent
Grapsoid "	22	" "	41+	"	"
Spider "	26	" "	39+	"	"
Total of three groups	75	species, or	40−	per	cent of all

Then the insignificant influence that northern species play in the Gulf of California fauna, may be visualized by a glance at the following table.

Northern intrusion of species in the Gulf of California.

Cancroid crabs, northern species	11	or	14+	per	cent
Grapsoid " " "	5	"	9+	"	"
Spider " " "	8	"	12+	"	"
Total of three groups	24	or	12+	per	cent of all

A recapitulation of the foregoing tables, based on a total for the three groups of 195 definitely allocated species, (two of the 197 species are doubtful in this locality), is as follows:

Panamian species in the Gulf, total	96	species, or	48+	per	cent

Indigenous species in the Gulf, total 75 species, or 40− per cent
Northern " " " " " 24 " " 12+ " "

There have been three expeditions in the Gulf of California which have added materially to our knowledge of the fauna of that region. They were, the two *Albatross* expeditions of 1891 and 1911, and the expedition of the California Academy of Sciences in 1921. As before stated it was my good fortune to collect in this territory during part of the years 1931–32–33. A partial summary of the results of this collecting, confined to the three before mentioned groups is:

Cancroid crabs, total of species	....	47 or 61+	per cent of species
Grapsoid " " " "	...	32 " 60+	" " " "
Spider " " " "	...	33 " 50+	" " " "
Total of species taken		112 or 56+	per cent

Many new locality records were obtained, extending the range of some species more than 25° of Latitude to the north. In the list of species to follow no extension of range is indicated if the distance is less than 100 miles, nor is extension of range given to that species unless specimens were collected at new localities. In all 46 new locality records are recorded, 18 of these are introductions to the fauna of the Gulf.

As a great deal of the information in this paper is of necessity a compilation, I wish to express my deep appreciation to Dr. Mary J. Rathbun of the United States National Museum, not only for her monographs but also for her personal attention to my efforts.

To facilitate reference to the list of species reported from the Gulf of California, these symbols are used after the name of the author of the species.

A	Indicates	Panamian species
B	"	Northern species, those found on west coast of North America, north of Magdalena Bay, Lower California.
C	"	Indigenous species
D	"	Apparently indigenous species extending their range a short way either north or south of Cape St. Lucas.
E	"	Species collected by the author.
F	"	New locality records of this collection.
(?)	"	*Tentative identification*

Spider Crabs

MAJIDAE

Stenorynchus debilis (Smith) A E
Podochela vestita (Stimpson) C E
Podochela hemphillii (Lockington) B E
Podochela latimanus (Rathbun) C E
Inachoides laevis Stimpson A E F
Erileptus spinosus Rathbun B E F

Eucinetops lucasii Stimpson C
Eucinetops rubella Rathbun C E
Eucinetops panamensis Rathbun A E
Euprognatha bifida Rathbun B E
Collodes granosus Stimpson C
Collodes tenuirostris Rathbun C D
Collodes tumidus Rathbun C D
Batrachonotus nicholsi Rathbun C D
Pyromaia tuberculata (Lockington) A B E
Dasygyius depressus (Bell) A E
Acanthonyx petiverii Milne Edwards A E
Epialtus sulcirostris Stimpson C D
Epialtus minimus Lockington C E
Eupleurodon trifurcatus Stimpson C
Taliepus nuttallii (Randall) B
Pugettia venetiae Rathbun B
Mimulus foliatus Stimpson B
Leucippa pentagona Milne Edwards A
Sphenocarcinus agassizi Rathbun A
Pelia tumida (Lockington) B C
Notolopas lamellatus Stimpson A E F
Herbstia camptacantha (Stimpson) C D
Herbstia parvifrons (Randall) B E
Herbstia tumida (Stimpson) C D
Libinia setosa Lockington C E
Libinia mexicana Rathbun C E
Lissa aurivilliusi Rathbun A
Lissa tuberosa Rathbun C
Hemus analogus Rathbun C E
Thoe sulcata Stimpson C D E
Pitho picteti (Saussure) A E
Pitho sexdentata Bell A E
Anoptychus cornutus Stimpson A E
Mithrax (Mithrax) spinipes Bell A E
Mithrax (Mithrax) orcutti Rathbun A
Mithrax (Mithrax) armatus Saussure C
Mithrax (Mithrax) tuberculatus Stimpson A
Mithrax (Mithrax) sinensis Rathbun C
Mithrax (Mithrax) sonorensis Rathbun C E
Mithrax (Mithraculus) denticulatus Bell A E
Mithrax (Mithraculus) areolatus (Lockington) A B
Teleophrys cristulipes Stimpson A
Stenocionops contigua Rathbun C E
Stenocionops macdonaldi (Rathbun) A
Stenocionops triangulata (Rathbun) A
Macrocoeloma heptacanthum (Bell) A
Macrocoeloma villosum (Bell) A
Microphrys platysoma (Stimpson) A E
Microphrys branchialis Rathbun C D E
Microphrys triangulatus (Lockington) A E

PARENTHOPIDAE

Parenthope (Parthenope) hyponca (Stimpson) A
Parthenope (Platylambrus) exilipes (Rathbun) A
Parthenope (Pseudolambrus) triangulata (Stimpson) C
Thyrolambrus erosus Rathbun C
Leiolambrus punctatissimus (Owen) A
Tyche lamellifrons Bell A E
Mesorhoea bellii (A. Milne Edwards) A E
Aethra scruposa scutata Smith A E
Cryptopodia hassleri Rathbun C E
Heterocrypta macrobrachia Stimpson A E F

Cancroid Crabs

PORTUNIDAE

Portunus (Portunus) xantusii (Stimpson) B E
Portunus (Portunus) asper (A. Milne Edwards) A
Portunus (Portunus) panamensis (Stimpson) A
Portunus (Achelous) brevimanus (Faxon) A
Portunus (Achelous) minimus Rathbun C E
Portunus (Achelous) pichilinquei Rathbun C E
Portunus (Achelous) affinis (Faxon) A
Portunus (Achelous) tuberculatus (Stimpson) A
Portunus (Portunus) iridescens (Rathbun) C
Callinectes bellicosus Stimpson C D E
Callinectes ochoterenai Contreras C
Callinectes arcuatus Ordway A E
Callinectes toxotes Ordway A
Arenaeus mexicanus (Gerstaecker) A E
Cronius ruber (Lamarck) A E
Euphylax robustus A. Milne Edwards C

ATELECYCLIDAE

Pliosoma parvifrons Stimpson C

CANCRIDAE

Cancer amphioetus Rathbun B
Cancer anthonyi Rathbun B
Cancer gracilis Dana B

XANTHIDAE

Carpilodes cinctimanus (White) A E F
Platypodia rotundata (Stimpson) A E F
Actea sulcata Stimpson A E F
Glyptoxanthus meandricus (Lockington) C E F
Daira americana Stimpson A E F
Lipaestheius leeanus Rathbun A E
Medaeus lobipes Rathbun A
Medaeus spinulifer (Rathbun) A
Cycloxanthops vittatus (Stimpson) A
Cycloxanthops novemdentatus (Lockington) B E F
Leptodius occidentalis (Stimpson) A E
Xanthodius sternberghi Stimpson A
Xanthodius hebes Stimpson C E F
Xanthodius stimpsoni (A. Milne Edwards) A E F
Lophoxanthus lamellipes (Stimpson) A E F
Metopocarcinus truncatus Stimpson A
Lophopanopeus heathii Rathbun B
Lophopanopeus frontalis (Rathbun) B E F
Lophopanopeus lockingtoni Rathbun B E
Lophopanopeus maculatus Rathbun C E
Panopeus purpureus Lockington A
Panopeus chilensis Milne Edwards and Lucas A
Panopeus bermudensis Benedict and Rathbun A E F
Panopeus diversus Rathbun C E
Neopanope peterseni Glassell C E
Hexapanopeus orcutti Rathbun O E F
Hexapanopeus sinaloensis Rathbun C E F
Hexapanopeus rubicundus Rathbun C E
Eurypanopeus ovatus (Benedict & Rathbun) C E F
Eurypanopeus planus (Smith) A
Eurypanopeus planissimus (Stimpson) C E F
Eurypanopeus confragosus Rathbun C E
Eurytium affine (Streets & Kingsley) C E
Eurytium albidigitum Rathbun C E
Micropanope latimanus Stimpson B
Micropanope xantusii (Stimpson) A E F
Micropanope polita Rathbun A E
Micropanope areolata Rathbun B E
Paraxanthias insculptus (Stimpson) A
Pilumnus xantusii Stimpson C
Pilumnus spinohirsutus (Lockington) B E
Pilumnus townsendi Rathbun C E
Pilumnus consalensis Rathbun C E
Pilumnus depressus Stimpson C
Pilumnus pygmaeus Boone A E F (?)
Pilumnus limosus Smith A E F
Pilumnus stimpsoni Miers C
Pilumnus tectus Rathbun C E
Heteractaea lunata (Milne Edwards & Lucas) A E F
Acidops fimbriatus Stimpson A E F
Ozius verreauxii Saussure A
Ozius perlatus Stimpson A E
Ozius agassizii A. Milne Edwards A E F
Eriphia squamata Stimpson A E F
Quadrella nitida Smith A
Trapezia digitalis Latreille A

Grapsoid Crabs

GONEPLACIDAE

Trizocarcinus dentatus (Rathbun) C
Euryplax polita Smith A E F
Speocarcinus granulimanus Rathbun C E
Speocarcinus californiensis (Lockington) B E F
Oediplax granulata Rathbun C
Glyptoplax pugnax Smith A E F
Chasmocarcinus latipes Rathbun C

PINNOTHERIDAE

Pinnotheres angelicus Lockington C E F
Pinnotheres lithodomi Smith A E F
Pinnotheres muliniarum Rathbun C
Pinnotheres goncharum (Rathbun) B E F
Pinnotheres pubescens (Holmes) C E
Pinnotheres margarita Smith A
Pinnotheres reticulatus Rathbun C
Pinnotheres jamesi Rathbun C
Pinnotheres pichilinquei Rathbun C
Fabia granti Glassell C E
Parapinnixa nitida (Lockington) C E F

Dissodactylus nitidus Smith A E F
Pinnixa transversalis (Milne Edwards & Lucas) A E F
Pinnixa tomentosa Lockington B E F
Pinnixa occidentalis Rathbun B
Pinnixa affinis Rathbun A
Tetrias scabripes Rathbun C

CYMOPOLIIDAE

Cymopolia sonata Rathbun C E F
Cymopolia lucasii (Rathbun) C
Cymopolia fragilis Rathbun A

GRAPSIDAE

Grapsus grapsus (Linnaeus) A E F
Geograpsus lividus (Milne Edwards) A E F
Goniopsis pulchra (Lockington) A E
Pachygrapsus crassipes Randall A B E
Pachygrapsus transversus (Gibbes) A E
Planes minutus (Linnaeus) A B E
Planes marinus Rathbun B
Goetice americanus Rathbun C E F
Tetragrapsus jouyi (Rathbun) C E F
Sesarma (Sesarma) sulcatum Smith A E F
Sesarma (Holometopus) magdalenensis Rathbun C E F
Cyclograpsus escondidensis Rathbun C E
Plagusia depressa tuberculata Lamarck A
Percnon gibbesi (Milne Edwards) A E F

GECARCINIDAE

Cardisoma crassum Smith A;
Ucides occidentalis (Ortmann) A
Gecarcinus planatus Stimpson A E

OCYPODIDAE

Ocypode occidentalis Stimpson A E F
Uca monilifera Rathbun C E
Uca princeps (Smith) A
Uca mordax (Smith) A E F
Uca brevifrons (Stimpson) A
Uca macrodactylus (Milne Edwards & Lucas) A
Uca crenulata (Lockington) B D E
Uca coloradensis (Rathbun) C E
Uca musica Rathbun C E F
Uca latimanus (Rathbun) A E

ZOOLOGY.—*The morphology and development of the preparasitic larvae of* Poteriostomum ratzii.[1] JOHN T. LUCKER, Bureau of Animal Industry. (Communicated by BENJAMIN SCHWARTZ.)

INTRODUCTION

The preparasitic larvae of the numerous species of small strongyles (Strongylidae of genera other than *Strongylus*) parasitic in the large intestine of horses have not been described, except in the case of *Triodontophorus tenuicollis*. The literature relating to this group of nematodes contains a number of publications dealing with the structure and development of their free-living larvae, but the available information is without reference to species, with the one exception noted above. The following is a brief summary of the literature pertaining to the preparasitic development of the small strongyles of horses.

In 1866, Baillet (3) published observations on the preparasitic development of *Sclerostoma tetracanthum* Diesing, 1851. As is well

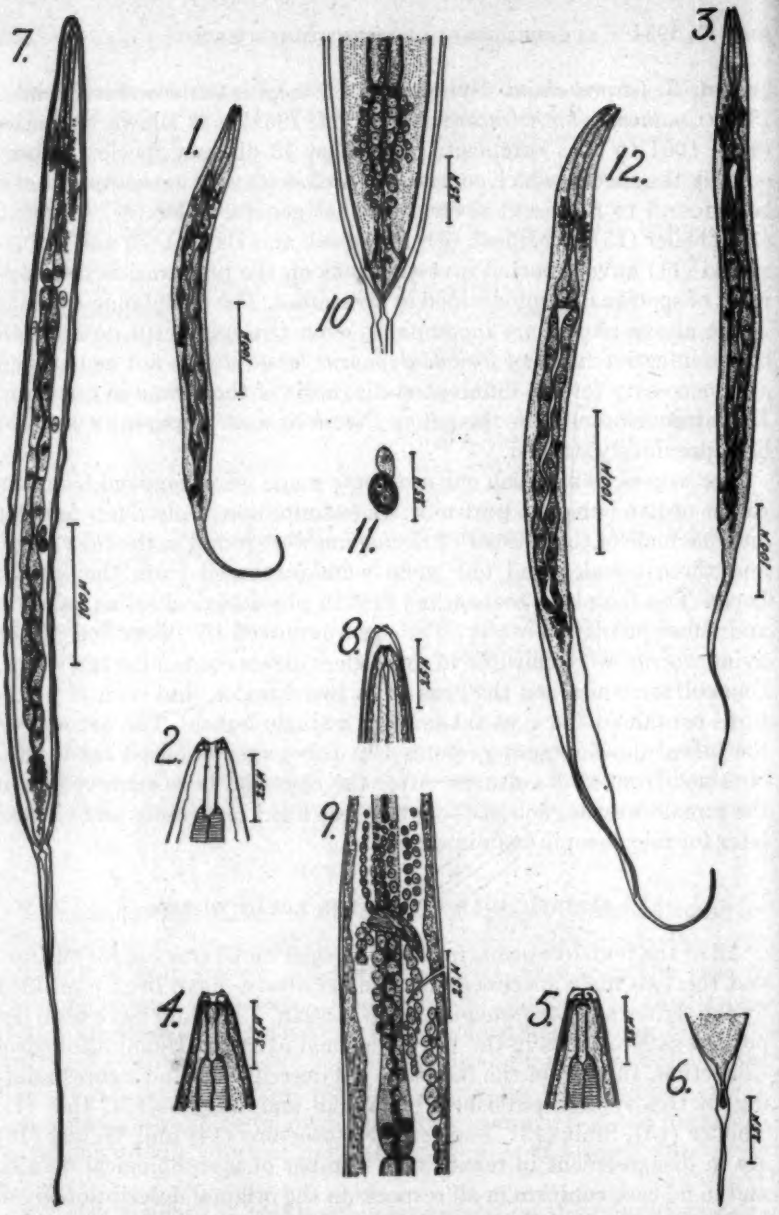
[1] Received March 2, 1934.

known, *S. tetracanthum* (Synonyms: *Strongylus tetracanthus* Mehlis, 1831; *Cyathostomum tetracanthum* Molin, 1861) was shown by Looss (9) in 1901 to be a composite of at least 13 distinct species. Subsequently the species which comprised the *S. tetracanthum* complex have been found to represent several distinct genera. Giles (6), Albrecht (1), Theiler (15), De Blieck (4), De Blieck and Baudet (5) and Poluszynski (11) have reported investigations on the preparasitic development of specifically unidentified cylicostomes. The morphological data in the above papers are incomplete; even Ortlepp's (10) description of the infective larva of *Triodontophorus tenuicollis* is not as detailed as is necessary for the differential diagnosis of the larvae in question. Larval development in the genus *Poteriostomum* apparently has not been previously studied.

The worms from which cultures were made were removed from the colons of two horses at post-mortem examination. Only a few females and one male of the genus *Poteriostomum* were found in the first horse, and three females and one male were recovered from the second horse. The females were washed first in physiological saline solution and subsequently in water. The eggs, removed by dissection of the living worms, were cultured in small glass dishes containing tap water. One culture contained the eggs from two females, and each of 4 cultures contained the eggs taken from a single female. The account of the larval development presented in this paper is based upon data obtained from all 5 cultures. After the eggs had been removed from the female worms each of the latter was fixed separately and cleared later for microscopic examination.

SPECIFIC IDENTITY OF THE ADULT WORMS

All of the female worms, from which eggs were removed for culture, and the two male specimens mentioned above, have been identified by the writer as *Poteriostomum ratzii* Kotlán, 1919, and have been deposited as No. 31026 in the U. S. National Museum Helminthological Collection. In view of the fact that the descriptions and figures relating to this species published by Yorke and Macfie (17), Ihle (7), Theiler (15), Smit (13), Smit and Notosoediro (14) and Wetzel (16) are in disagreement in regard to a number of morphological details, and in no case conform in all respects to the original description given by Kotlán (8), the following brief comments as to certain morphological features of the writer's specimens are in order. There are from 64 to 84 elements in the external leaf crown (Kotlán reported from 60



Figs. 1–12.—*Poteriostomum ratzii*. Preparasitic larval stages.

Fig. 1.—First-stage larva, newly hatched. Fig. 2.—First-stage larva, anterior end. Fig. 3.—Second-stage larva. Fig. 4.—Second-stage larva, anterior end. Fig. 5.—Second-stage larva, anterior end, during late phase of development. Fig. 6.—Late second-stage larva, posterior end. Fig. 7.—Infective (third-stage) larva. Fig. 8.—Third-stage larva, anterior end. External edge of sheath inadvertently omitted. Fig. 9.—Third-stage larva, region of nerve ring. Fig. 10.—Third-stage larva, posterior portion. Fig. 11.—Third-stage larva, genita primordium. Fig. 12.—First-stage larva in first ecdysis.

to 64 elements; Smit noted 44 elements; Wetzel reported from 44 to 46 elements; Ihle counted 98 elements in one specimen). The internal leaf crown contains from 38 to 48 elements (Kotlán reported from 40 to 44 elements; Ihle counted 48 elements in one case; Wetzel reported from 34 to 38 elements; Smit noted 30 elements). The structure of the 4 submedian and 2 lateral papillae corresponds to the descriptions of Ihle and Wetzel and to the figure of Yorke and Macfie. In respect to the shape of the walls of the mouth capsule, the specimens agree closely with the figure of Yorke and Macfie and with the description given by Wetzel. The dorsal ray pattern is similar to that figured by Smit and by Smit and Notosoedirо, except that the lateral dorsal rays are even more widely separated from one another than noted by the above mentioned workers.

P. ratzii var. *nanum* of Theiler, which has been redescribed as a sub-species by Popov (12), has been differentiated from *P. ratzii* principally because the postero-lateral rays in the former are without an "accessory" process near their base. A definite small posterior cuticular swelling or process is present on these rays in the males collected by the writer.

DESCRIPTION OF THE EGG, PRE-INFECTIVE AND INFECTIVE LARVAE

Egg

Usually elliptical in shape, but may be slightly narrower at one pole than at the other. Shell thin and transparent. Measurements of a comparatively small number of eggs showed a wide variation in size, namely from 90μ to 125μ in length and from 57μ to 70μ in width. Eggs present in the uterus near the vagina were in the 16- or 32-cell stage. When fully developed the vermiform embryo has the structure of the first-stage larva described below.

First-stage larva

Shape and size.—Fusiform; similar in appearance to rhabditiform larvae of related strongyles, a long filamentous tail comprising about $\frac{1}{4}$ to $\frac{1}{8}$ of the body length (Fig. 1). Newly hatched larvae from 450μ to 470μ long; larvae at time of first molt, 600μ to 620μ long.

Cuticle.—Thin, with very inconspicuous transverse striations.

Alimentary tract.—Mouth opening surrounded by minute papillae, apparently 6 in number. In the rhabditiform buccal cavity, cheilorhabdions and telorhabdions, (Fig. 2) represented by definite refractive cuticular dots; prorhabdions and metarhabdions discernible as short refractive cuticular rods, refractive dots appearing at their junctures. Esophagus rhabditiform; esophageal valve prominent. Esophagus and intestine united by primordium of esophago-intestinal valve; valve consisting of 4 cells and with a short, narrow, straight lumen. Intestinal lumen dilated and sinuous in living

specimens, expanded terminally both anteriorly and posteriorly. In living specimens the intestine dark and granular, consisting apparently of 16 cells. Lumen of rectum narrow, leading to a conspicuous anus. Rectal glands dorsal and subventral to rectum.

Nervous system.—Nerve ring surrounding isthmus of esophagus. Numerous nerve cells situated lateral and ventral to esophagus both anterior and posterior to nerve ring.

Excretory system.—Excretory pore and excretory canal not seen.

Genital primordium.—Primordium minute, oval, transparent, containing 2 germinal cells, situated ventral to and at approximate equator of intestine. In some specimens, genital primordium in close apposition to a smaller, more anterior, oval or spade-shaped cell, presumably the "giant cell" mentioned by Alicata (2) as of significance in sex differentiation in larvae of *Hyostrongylus rubidus*.

The size relationships of 10 first-stage larvae are given below in Table 1.

TABLE 1.—SIZE RELATIONSHIPS OF 10 FIRST-STAGE LARVAE OF POTERIOSTOMUM

ALL MEASUREMENTS IN MICRONS

Specimen number	1	2	3	4	5	6	7	8	9	10
Length	620	554	535	516	474	456	470	583	576	485
Width in region of esophageal bulb	30	32	35	28	26	25	27	29	27	25
Length of buccal capsule	17	15	16	13	13	12	12	14	14	14
Distance from anterior end to nerve ring	102	98	105	90	80	70	70	94	91	82
Length of esophagus	130	129	140	115	122	112	116	121	132	120
Distance from bulb of esophagus to genital primordium	117	141	109	117	102	105	103	127	119	100
Distance from genital primoridum to anus	165	104	120	121	109	118	110	135	122	118
Length of tail	190	174	169	153	130	104	127	186	189	131

Second-stage larva

Shape and size.—Similar in shape to first-stage larva; 600μ to 850μ long, the latter being the approximate maximum length attained during preparasitic stages (Fig. 3). During early phases of this stage, tail increasing considerably in absolute length and, as a rule, in proportionate length also. During transition to strongyliform third stage, tissue of tail loosening from cuticle and contracting to form a short, round-tipped process (Fig. 6).

Cuticle.—Thick and very prominently striated; great thickening occuring in tail region during the later phases of this stage.

Alimentary tract.—In young larvae of this stage, alimentary canal similar to that of first-stage larva. During transition to strongyliform stage the following changes occur: Prorhabdions of buccal capsule at first curving toward each other anteriorly (Fig. 4), later uniting (Fig. 5) to form an inverted V, other portions of the buccal capsule becoming reduced; esophagus lengthening slightly, losing its rhabditiform character and assuming a strongyliform structure; meanwhile esophageal valve disappearing, and primordium of esophago-intestinal valve becoming syncytial; boundaries of intestinal cells becoming more distinct, posterior 2 cells being set off by a constriction as a pre-rectum. Anus appearing somewhat less conspicuous than in first-stage larva.

Nervous system.—Similar to that of the first-stage larva, but nerve cells more prominent.

Excretory system.—Excretory pore and excretory duct clearly visible anterior and ventral to esophageal bulb and just posterior to nerve ring.

Genital primordium.—Similar to that of first-stage larva, but slightly larger and containing a greater number of epithelial cells.

The size relationships of 7 second-stage larvae are shown below in Table 2.

TABLE 2.—SIZE RELATIONSHIPS OF 7 SECOND-STAGE LARVAE OF P. RATZII
ALL MEASUREMENTS IN MICRONS

Specimen number	1	2	3	4	5	6	7
Length	654	830	640	631	790	629	668
Width in region of esophageal bulb	26	37	27	29	35	27	28
Length of buccal cavity	14	19	16	17	19	14	14
Distance from anterior end to nerve ring	101	110	106	93	82	82	90
Distance from anterior end to excretory pore	112	135	117	117	130	93	100
Length of esophagus	138	145	134	139	141	115	135
Distance from bulb of esophagus to genital primordium	140	165	143	102	159	112	150
Distance from genital primoridum to anus	138	225	136	145	163	148	169
Length of tail	222	279	211	228	310	240	200

Third-stage larva

Shape and size.—Fusiform; tail short, slightly tapering, rather suddenly constricted near its distal end and terminating in a minute, rounded, thumb-like process. Larva from 443μ to 584μ long in 10 specimens. Average width in esophago-intestinal region, about 29μ.

Cuticle.—Thinner than that of second-stage larva and finely striated.

Sheath.—Very thick, with wide, prominent, transverse striae. Two median longitudinal prominences extending along lateral surfaces of sheath; these probably represent lateral alae; sheath conforming closely to shape of larva, but extending posteriorly from 200μ to 255μ beyond posterior tip of larva as a fine tapering cuticular tube or tail; sheath rather sharply constricted just posterior to region normally occupied by larval tail when larva is fully extended. At point of constriction, walls of sheath greatly thickened (Figs. 7, 10) for a short distance, enclosing a very narrow lumen; walls becoming thinner again immediately posteriorly, the narrow lumen mentioned above being very short and followed by a more expanded lumen becoming increasingly narrow as walls converge posteriorly to form tapering distal portion of sheath's tail.

Alimentary tract.—Oral opening surrounded by papillae and followed by a short, narrow, slightly cuticularized tube or canal leading into a minute oval cavity; this cavity communicating with a vestibule by means of a short canal. Vestibule variable in size, but conforming in optical section to the following general plan of structure: Anterior margin of vestibule formed by an inconspicuously cuticularized inverted V, apparently a residue of previous stage prorhabdions; lateral walls cuticular, rather strongly refractive, probably the residuum of metarhabdions of previous stage, converging posteriorly to unite with esophageal lumen; greater part of vestibulum surrounded by esophageal tissue (Fig. 8). Esophagus strongyliform; its lumen highly refractive. Frequently 2 prominent nuclei visible within bulb of esophagus,

specimens, expanded terminally both anteriorly and posteriorly. In living specimens the intestine dark and granular, consisting apparently of 16 cells. Lumen of rectum narrow, leading to a conspicuous anus. Rectal glands dorsal and subventral to rectum.

Nervous system.—Nerve ring surrounding isthmus of esophagus. Numerous nerve cells situated lateral and ventral to esophagus both anterior and posterior to nerve ring.

Excretory system.—Excretory pore and excretory canal not seen.

Genital primordium.—Primordium minute, oval, transparent, containing 2 germinal cells, situated ventral to and at approximate equator of intestine. In some specimens, genital primordium in close apposition to a smaller, more anterior, oval or spade-shaped cell, presumably the "giant cell" mentioned by Alicata (2) as of significance in sex differentiation in larvae of *Hyostrongylus rubidus*.

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Alimentary tract.—In young larvae of this stage, alimentary canal similar to that of first-stage larva. During transition to strongyliform stage the following changes occur: Prorhabdions of buccal capsule at first curving toward each other anteriorly (Fig. 4), later uniting (Fig. 5) to form an inverted V, other portions of the buccal capsule becoming reduced; esophagus lengthening slightly, losing its rhabditiform character and assuming a strongyliform structure; meanwhile esophageal valve disappearing, and primordium of esophago-intestinal valve becoming syncytial; boundaries of intestinal cells becoming more distinct, posterior 2 cells being set off by a constriction as a pre-rectum. Anus appearing somewhat less conspicuous than in first-stage larva.

Nervous system.—Similar to that of the first-stage larva, but nerve cells more prominent.

Excretory system.—Excretory pore and excretory duct clearly visible anterior and ventral to esophageal bulb and just posterior to nerve ring.

Genital primordium.—Similar to that of first-stage larva, but slightly larger and containing a greater number of epithelial cells.

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Length of tail	222	279	211	228	310	240	200

Third-stage larva

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Cuticle.—Thinner than that of second-stage larva and finely striated.

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presumably being nuclei of esophageal glands. Esophagus leading to a 16-celled intestine; boundaries of intestinal cells definite in young third-stage larvae, but becoming indistinct with exhaustion of reserve food material. Lumen of rectum narrow, leading to an inconspicuous anus.

Nervous system.—Nerve ring slightly posterior to equator of esophagus. In fixed and stained specimens the following details of the nervous system were observed (Fig. 9): 6 narrow chains of nerve cells passing anteriorly from nerve ring about one half distance to cephalic end; nerve fibres not traced from this point anteriorly. A small ganglion posterior and dorsal to nerve ring, laterally a large ganglion passing posteriorly along each side of esophagus and extending nearly to bulb. A ventral ganglion of somewhat smaller size also visible. A chain of nerve cells extending posteriorly from retrovesicular ganglion toward 2 large median ganglia in caudal region. Caudal papillae or phasmids (Fig. 10) about 15μ to 18μ from tip of tail, connecting with tubes or canals passing internally and anteriorly from phasmids. The further course of these canals could not be traced owing to the large number of nerve cells present in this region.

Excretory system.—Excretory pore slightly posterior to nerve ring. Excretory canal or duct passing inward and posteriorly from excretory pore to join a transverse excretory duct. A cross section of lumen of transverse duct visible in optical section of living specimen. Walls of transverse duct contracting and expanding at irregular intervals.

Genital primordium.—Gross appearance similar to that of preceding stages, its position being ventral to the fourth and fifth ventral intestinal cells. The two large germinal cells rather centrally located and surrounded by 11 epithelial cells (Fig. 11). In addition to the "giant cell" near genital primordium, 3 similar cells occuring in body cavity anterior to genital primordium.

The size relationships of 10 third-stage larvae are given below in Table 3.

TABLE 3.—SIZE RELATIONSHIPS OF 10 THIRD-STAGE LARVAE OF P. RATZII
ALL MEASUREMENTS IN MICRONS

Specimen number	1	2	3	4	5	6	7	8	9	10
Length of sheath	737	845	649	706	685	743	712	802	718	762
Distance from posterior end of larva to posterior tip of sheath	211	261	206	253	242	232	205	253	211	220
Length of larva	526	584	443	453	443	511	507	549	507	542
Width of larva in region of esophageal bulb	26	31	20	28	29		24	30		26
Width of sheath in region of esophageal bulb	34	35	25	34	35		30	34		34
Distance from anterior end to nerve ring	94		77	91	90	99	96	98	96	108
Distance from anterior end to excretory pore	115		96	110	110	118	115	115	121	120
Length of esophagus	183	180	162	148	158	180	174	173	180	179
Distance from bulb of esophagus to genital primordium	141	183	124	142	112	146	120	134	149	172
Distance from genital primordium to anus	166	179	117	130	142	151	180	205	146	149
Length of tail	36	40	32	30	34	34	34	38	31	42

DEVELOPMENT OF PREPARASITIC LARVAL STAGES

In water cultures at room temperatures (20° to 26° C.), most eggs contained a vermiform embryo 24 hours after the cultures were pre-

pared. Some eggs hatched within 22 hours and nearly all of the eggs hatched within 40 hours. When the first-stage larvae issued from the eggs, a small amount of helminthologically sterile fecal extract was added to the culture medium. In one culture, after 67 hours of incubation, larvae were observed in the act of casting off the first cuticle (Fig. 12). While the first molt was not actually observed, in two other cases a large number of discarded sheaths were found in the culture dishes examined 72 hours after the cultures were started. In these two cultures all larvae were still in the first stage after 48 hours. Third-stage larvae were found in some cases as early as 115 hours after the cultures were prepared. The thick cuticle of the second-stage larva was not cast off, but was retained by the third-stage larva as a sheath.

SUMMARY

The first-stage larva of *P. ratzii* hatches from the egg in from 22 to 40 hours when kept in water cultures at room temperature (20° to 26° C.); the larva is rhabditiform, varies in length from 450μ to 620μ, and is provided with a long filamentous tail.

The first molt was observed after about 67 hours in a water culture to which helminthologically sterile fecal extract had been added shortly after the first-stage larvae issued from the eggs.

The early second-stage larva is similar to larvae of the preceding stage except that its cuticle is thick and prominently striated. Shortly after the first molt, the excretory pore and excretory canal become clearly visible. Second-stage larvae are from 600μ to 850μ long.

As development proceeds, the second-stage larva becomes further differentiated morphologically. Following the formation of a new cuticle and the attainment of the strongyliform structure, the old cuticle loosens from the body and the larva enters the ensheathed third stage. The second cuticle is not cast off.

The third-stage strongyliform larva has a short tail and is from 443μ to 585μ long. The sheath in which the larva is enclosed is from 650μ to 850μ long, and is characterized by great thickening of its walls in the region immediately posterior to that occupied by the tail of the fully extended larva. A minimum of 115 hours was required for the development from the uterine egg to the infective larva.

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ORNITHOLOGY.—*The hawks of the genus* Chondrohierax.[1] HERBERT FRIEDMANN, U. S. National Museum.

The hook-billed kites of the genus *Chondrohierax* have always been a source of much confusion to taxonomists because of their unusual range of variation in color and size and because of their scarcity in collections. Recently while working over these birds, I

[1] Published by permission of the Secretary of the Smithsonian Institution. Received March 21, 1934.

took the opportunity of bringing together by far the most extensive series of specimens ever assembled and am greatly indebted to the following institutions and their staffs for the loan of material: The American Museum of Natural History, New York (Mr. J. T. Zimmer); the Museum of Comparative Zoology, Cambridge (Mr. J. L. Peters); The Academy of Natural Sciences, Philadelphia (Dr. W. Stone and Mr. M. A. Carriker); the Carnegie Museum, Pittsburgh (Mr. W. E. C. Todd); the University of Michigan Museum, Ann Arbor (Dr. J. Van Tyne); and the California Institute of Technology (Mr. A. J. van Rossem). The specimens assembled total 100 in number; in addition to these Dr. Percy R. Lowe has kindly sent me measurements and geographical data concerning 10 specimens in the British Museum.

If we take Peters' Check List of the Birds of the World (vol. 1: 200. 1931) as a statement of current treatment of the genus, we find three species with no races: *uncinatus*, *megarhynchus*, and *wilsonii*. The last one, restricted to Cuba, is easily disposed of. It is readily told by its yellowish upper mandible. The real problems deal with *uncinatus* and *megarhynchus*. On glancing through the literature, we find that no two authorities give the same range for *megarhynchus*, which is said to differ from *uncinatus* only in having a larger bill. This immediately aroused suspicion as to the validity of the race and was the chief reason for gathering together specimens from all parts of the ranges of the two (tropical Mexico to Bolivia and northern Argentina). However, before it was possible to approach the geographic variations in these birds, obviously conspecific and not, as often stated, distinct species, it was necessary to work out their exceedingly complicated and puzzling plumage sequence. The following detailed description of the plumages of *uncinatus* reveals varieties within phases, certainly a most unusual degree of variability. There are only two real steps in the sequence—juvenal and adult, but both are complex.

PLUMAGES OF C. UNCINATUS UNCINATUS

Adult male

a. Gray phase.—Above dark plumbeous, or plumbeous-black, becoming fuscous, or fuscous-black in worn plumage; the occiput with much basal white and the upper tail coverts tipped and banded with white. Sides of face, ear coverts, and chin deep to dark plumbeous; under tail coverts white to ochraceous-buff, uniform, or with traces of grayish bars occasionally distinctly banded with plumbeous. Remainder of under parts deep plumbeous (usually paler than the upperparts) barred with narrow bands of white, buff, or cinnamon-buff, which are variable in width, and are usually nar-

rowly bordered by fuscous or fuscous-black. Axillaries and under wing coverts uniform deep plumbeous, barred with white or buff; primaries banded (about equally) with white and plumbeous-black below, dark plumbeous and plumbeous-black above, the outer webs often uniform plumbeous-black; secondaries uniform dark plumbeous, occasionally with traces of lighter bars below. Tail plumbeous-black to black, white basally, narrowly tipped with white or deep mouse-gray, and crossed by two bands (the anterior one the narrower) of white, or pinkish-buff, shading to deep mouse-gray posteriorly and towards the outer webs, which are often uniform mouse-gray above. Bill black, olive below; iris greenish white; feet orange-yellow, claws black.

Unbarred variety.—Similar to the above description, but lacking entirely or partially the white barring on the under parts.

Cinnamon-barred variety.—Similar to the above description, but with the gray barring of the under parts more or less replaced by cinnamon-brown or russet, and with more or less indication of a cinnamon or ochraceous-tawny nuchal collar.

b. Melanistic phase.—Entire plumage deep fuscous black, with a slight bronze-purple-green gloss; the occiput with much basal white; tail narrowly tipped with white, and crossed by a single broad white band. Bill black above, dirty olive below, tipped with black; cere and eyelids yellowish green; skin in front of eye blue-green, spot above inner angle of eye orange-yellow; iris white; feet gamboge.

Adult female.

a. Brown phase.—Forehead, auriculars, and sometimes the chin deep gull-gray to deep neutral gray, or dark plumbeous; crown and occiput fuscous to fuscous-black, with concealed white bases; a broad, continuous nuchal collar of ochraceous-buff, tawny, or amber-brown occasionally extending to the ear coverts; remainder of upper parts fuscous to fuscous-black, darker anteriorly, often with slightly paler (sometimes russet) edges to the feathers; upper tail coverts tipped and barred with white or pale gray. Entire under parts, including under wing coverts, white, or ochraceous-white (more ochraceous on the under tail coverts,) with broad nearly equal transverse bars of ochraceous-tawny, cinnamon-brown, russet, or amber-brown, narrowly edged with fuscous or fuscous-black (occasionally this edging is absent, and sometimes it widens to spread over almost the entire bar). Outer primaries pale fuscous above, white, or pale mouse-gray below, cream color, or pinkish buff toward the bases of the inner webs, and distantly banded with fuscous, or fuscous-black (the bands being about one half or one third the width of the lighter interspaces); inner primaries chestnut, or russet, shading to creamy or pinkish buff towards the bases of their inner webs, and distantly banded with fuscous; secondaries light fuscous above, gull-gray below, white, or cream color toward the bases of the inner webs, and somewhat indistinctly banded with dark fuscous. Tail fuscous-black, to black, white basally, narrowly tipped with white or paler hair-brown, and crossed by two bands of hair-brown or mouse-gray, shading to white or pinkish buff on the inner webs, especially anteriorly. Bill black, yellowish olive below; lores olive-orange; sides of cere olive-yellow; spot above eye orange; skin in front of eye grass-green; iris white; feet gamboge.

Gray-backed variety.—Like the above, but with the upper parts plumbeous-black to sooty-black, and with a tendency toward loss of the tawny nuchal

collar. Females in this plumage variation are very like the cinnamon-barred variation of the gray phase of the male.

b. Melanistic phase.—Similar to that of the male.

Immature.

No definite immature plumage; there is a gradual, and probably prolonged molt from juvenal to adult, which appears to commence anteriorly, as well as on the underparts, and to end with the tail.

Juvenal (sexes alike).

a. Light phase.—Forehead, crown, and occiput fuscous-black with white bases to the feathers; a broad, white, cream, or pinkish-buff, nuchal collar, continuous with the white under parts; remainder of upper parts fuscous (shading to fuscous-black on the neck) with narrow cinnamon-tawny or russet margins to the feathers; upper tail coverts tipped and barred with white, or pinkish buff. Entire under parts white, or buff, shading to pinkish buff on the thighs and under tail coverts and either uniform, or distantly barred with hair brown, olive-brown, or fuscous (the number and width of these bars varies considerably); outer primaries fuscous above, creamy white towards the bases of the inner webs, and pallid neutral-gray below, barred with fuscous-black; inner primaries with more or less orange-cinnamon to cinnamon-rufous on both webs; secondaries fuscous above, with some white, or buff, on the inner webs, mouse-gray below, and barred with darker fuscous. Tail fuscous-black, basally white, narrowly tipped with white, cream, buff, or pinkish cinnamon, and crossed with three, or four pale bands, which are uniform hair-brown to light fuscous, on the central pair, and irregularly marked with white, cream, buff, or pinkish cinnamon on the remainder.

b. Melanistic phase.—Forehead, crown, and occiput fuscous-black to sooty black; remainder of upper parts fuscous to fuscous-black, the feathers with concealed white bars or spots near their bases; upper tail coverts tipped and widely barred with white. Entire under parts fuscous to fuscous-black, with concealed white bars on the bases of the feathers, the under tail coverts tipped also with white, or buff; wings fuscous-black crossed by three or four paler bars which are white basally, fuscous above, pale neutral gray below distally. Tail fuscous-black to sooty black, white basally, tipped with white, and crossed by two bands of white, shaded, or marked (especially on the distal band) with hair-brown or mouse gray (that is, the tail pattern like that of the non-melanistic adult).

THE HOOK-BILLED KITES OF GRENADA

The specimens of *uncinatus* from the island of Grenada prove to be constantly smaller than those of the South American mainland or from Trinidad and to have certain color differences as indicated below. For this distinct race I propose the name

Chondrohierax uncinatus mirus subsp. nov.

Type: Adult male, American Museum Nat. Hist., 45054, collected on March 26, 1885, at Morne Rouge, Grenada, by J. Grant Wells.

Subspecific characters.

Adult male.—Similar to the cinnamon-barred variety of the gray phase of *C. u. uncinatus*, but smaller, and with nuchal collar well developed, cinnamon-buff to ochraceous-buff, and the barring on the under parts ochrac-

eous-tawny to tawny, with little or no grayish edgings to the bars. Iris pale green; bill and feet (in dried skins) like those of *C. u. uncinatus*.

Adult female.—Similar to the brown phase of *C. u. uncinatus*, but smaller and differing in the following respects: top of head deep fuscous, with little or no indication of gray; nuchal collar, extending to the ear coverts and cheeks, ochraceous-buff to ochraceous-tawny; upper parts fairly widely edged with tawny or cinnamon-rufous; barring on under parts more ochraceous-tawny to tawny, and with little or no indication of brown edgings.

Immature and *Juvenal*.—Not known.

Adult male (one specimen (type)).—Wing 250; tail 165; culmen from base of cere 28.0; tarsus 30.0; middle toe without claw, 25 mm.

Adult female (three specimens—one sexed "male," another not sexed, but undoubtedly female).—Wing 262–266 (264.3); tail 179–183 (181.3); culmen 30.0–30.5 (30.3); tarsus 30.0–36.0 32.3; middle toe without claw 29.0–34.0 (31.0).

Range: The island of Grenada, where resident.

It is said by observers who have worked in Grenada that the birds there never attain the wholly gray phase found in South America, so that it seems that the island form is a case of arrested plumage development with a tendency to hen feathering in the males (the cinnamon bars of the underparts being essentially a female character in these birds). It is noteworthy that in specimens from Trinidad and Venezuela we find suggestions of hen feathering in males (the cinnamon-barred variety of the gray phase described in the account of the plumage sequence of typical *uncinatus*). In Grenada it has apparently become fixed.

Just as we find a tendency towards hen feathering in the males in this species so too we find signs of cock feathering in the hens in some instances. The gray-back phase of the adult female (represented by specimens from Surinam and Venezuela) is apparently to be so considered.

THE HOOK-BILLED KITES OF MEXICO

Examination of a good series of Mexican specimens reveals the fact that at least two subspecies of the hook-billed kite occur in that country. The birds inhabiting Tamaulipas, Jalapa, Guanajuato, and Jalisco are a very distinct race and may be known as

Chondrohierax uncinatus aquilonis subsp. nov.

Type.—Museum of Comparative Zoology 113711, adult male, collected in Tamaulipas, Mexico, April 9, 1900 (ex Worthen coll.).

Subspecific Characters.—Males very much darker, especially on the underparts, than *uncinatus*, blackish plumbeous instead of deep plumbeous, the white ventral bars broader than in topotypical *uncinatus*; females similar to the darker barred brown phase of typical *uncinatus* (the ventral bars russet or amber brown).

Measurements.—5 males—wing 279–300 (290), tail 186–210 (199), culmen from cere 29–33.5 (31.1) mm; 4 females—wing 275-300 (291.5), tail 191–214 (204.5), culmen from cere 30.5–33 (32.3) mm.

Range.—Tamaulipas, Jalapa, Guanajuato, and Jalisco. It is possible that

two very large birds from Guerrero are of this race, but the only male is in the melanistic phase and cannot be identified subspecifically. I consider them, together with Oaxaca, Quintana Roo, Chiapas, and Guatemalan birds as typical *uncinatus*.

THE UNCINATUS-MEGARHYNCHUS PROBLEM

The form *megarhynchus* was described by Des Murs in Castelnau's *Voyages*, volume 1, Oiseaux, 1855, page 9, plate 1, from Sarayacu, somewhere near the eastern part of the Ecuadorean-Peruvian border. The type locality of *uncinatus* is "Vicinity of Rio to the north of Brazil and all of Guiana." If we measure the culmen from the cere in the plate given by Des Murs, we find it to be 39 mm. The bird is, by plumage, a male. Now, if we take our series of adult *uncinatus* and tabulate their dimensions, we find two things, First, an enormous range of variation; second, no correlation between variation and geography.

Adult male (26 specimens): Wing 265–301 (285.8); tail 173–210 (191.1); culmen from cere 27.0–35.5 (31.3), one 42.0; tarsus 32.0–37.0 (35.1); middle toe without claw 28.0–35.0 (31.1).

Adult female (31 specimens): Wing 268–321 (289.4); tail 191–228 (202.8); culmen from cere 28.0–37.0 (31.6), one 43.5; tarsus 31.0–37.0 (33.8); one 28; middle toe, without claw 28.0–34.0 (30.9).

These measurements arranged geographically are presented in the tables on the following page.

At first glance we may see that birds from eastern Brazil (Bahia, within the original, vague type locality of *uncinatus*), from the Amazon, from Mexico (Chiapas, and Guerrero) and from western Ecuador all match the characters of *megarhynchus*. In other words, "*megarhynchus*" occurs here and there throughout the range of *uncinatus;* furthermore, there is no gap in the size variations between small *uncinatus* and large "*megarhynchus*." This continuity of variation and absence of geographical correlation point to but one conclusion: that *megarhynchus* cannot be regarded as a taxonomic entity in any way distinct from *uncinatus*. The problem, however, is not quite as simple as a bald statement of it implies. One specimen from Ambata Oriente, eastern Ecuador, and four from northeastern Peru (Cajamarca to Rio Huallaga) regions from which *uncinatus* has not been recorded, are so very much larger, in bill length, and also to some extent in the greater width of the rectrices that I cannot put them in with the merged *uncinatus-megarhynchus* series. These birds, which are described below, are apparently the climax in size of the whole species, and it appears that the birds from Ecuador, the Andes of Venezuela, eastern Brazil, and southern Mexico, that have appeared in literature as *megarhynchus* are variants of *uncinatus* in the direction of the Ambata-Peruvian birds. This race may be known as

Chondrohierax uncinatus immanis subsp. nov.

Type.—Museum of Comparative Zoology 149835, adult unsexed (female by plumage), collected at Ambata Oriente, on the eastern base of the eastern Andes, Ecuador, by Reinberg.

TABLE 1.—MEASUREMENTS OF 26 MALE SPECIMENS OF CHONDROHIERAX UNCINATUS UNCINATUS

Country	Number of Specimens	Wing	Culmen from Cere
Mexico (Guerrero)	1	301	42
Guatemala	3	281–299 (287.5)	30.0–33.0 (31.2)
Nicaragua	1	290	33.0
Panama	1	299	30.5
Venezuela	5	265–294 (280.4)	29.0–30.5 (29.8)
Surinam	3	272–291 (283.0)	28.5–30.5 (29.7)
Colombia	2	278–292	30.5–34.0
Ecuador	5	274–289 (284.3)	32.5–35.5 (34.3)
Peru	2	286–298	33.0–33.5
Brazil	2	275–285	27.0–29.5
Argentina	1	300	30.0

TABLE 2.—MEASUREMENTS OF 31 FEMALE SPECIMENS OF C. UNCINATUS

Country	Number of Specimens	Wing	Culmen from Cere
Mexico (Guerrero)	2	283–307	30.0–43.5
Guatemala	1	289	29.5
Nicaragua	1	290	32.5
Costa Rica	1	290	30.0
Venezuela	6	272–309 (287.8)	29.0–31.5 (29.9)
Surinam	2	285–289	28.0–30.5
Colombia	10	268–321 (285.0)	28.0–34.5 (31.4)
Ecuador	4	284–303 (290.8)	28.5–38.0 (33.6)
Peru	2	290–305	34.0–34.5
Brazil	2	293–295	30.0–37.0

TABLE 3.—MEASUREMENTS OF 10 SPECIMENS OF C. U. UNCINATUS SUPPLIED BY DR. P. R. LOWE

Locality	Sex	Wing	Tail	Culmen from Cere	Tarsus
Amazon	Unsexed	295	187	38	36
Brazil, Bahia	"	285 (worn)	194	40	37
Venezuela, Merida	"	289	200	31	34
" "	Male	297	205	31	38
Mexico, Chiapas, Tonala	Male	317	210	38	40
" Colotlan	Male	291	205	30	35
" Chiapas, Tonala	Female	308	213	34	36
" "	Female	305	217	36	39
" "	Female	296	205	35	37
" Oaxaca	Female juv.	292	218	36	36

Subspecific Characters.—Distinguished from *uncinatus* by its huge bill and broad rectrices; wing 317, tail 228, culmen from cere 50 mm.

Adult male.—(2 specimens, Shapaja on the Rio Huallaga, and Chaupe, Cajamarca Province): Wing 315, 319; tail 205, 228; culmen from cere 45, 50 mm.

Adult female.—(3 specimens including the type; Ambata Oriente, Ecuador; Chaupe, Cajamarca Province and Rio Jelashte, San Martin, Peru): Wing 306, 314, 317; tail 225, 228, 229; culmen from cere 48, 50, 50 mm.

Range.—Ambata Oriente, Ecuador, to northeastern Peru (Shapaja, Rio Huallaga; Rio Jelashte, San Martin; and Chaupe Cajamarca).

Remarks.—It may seem strange to describe as new a form from a place not far from the type locaity of *megarhynchus* (which is here relegated to the synonymy of *uncinatus*) but, as is shown above, "*megarhynchus*" has no discrete range or dimensional limits outside the variational range of typical *uncinatus*. By describing *immanis*, *megarhynchus* is caused to assume its correct place as an intermediate between *uncinatus* and *immanis*, as it should be on geographic grounds. The "*megarhynchus*" type of individuals from Mexico, Venezuela, and eastern Brazil, cannot, of course, be said to be intermediates between *uncinatus* and the geographically remote *immanis*, but they are variants in the direction of the latter.

VARIATIONS, TYPE LOCALITY, AND RANGE OF C. U. UNCINATUS

Males in the gray phase vary slightly from north to south in the width of the white ventral bars, the bars becoming narrower on the average in Peru, the Guianas, Brazil, and Argentina, and broader in Central America, but the difference is very slight. Peruvian males (2) are a little darker gray on the underparts than specimens from other South American countries, but again the difference is a faint one.

As stated above, the locality given by Temminck in the original description of this bird is very broad—from Rio de Janeiro to all of the Guianas. This has never been restricted as far as I know; I hereby restrict it to the vicinity of Paramaribo, Surinam.

The range of the nominate form of the hook-billed kite is as follows: marshy and swampy places in the tropical zone from southern Mexico (Guerrero, Oaxaca, Yucatan, and Chiapas) south through Guatemala, Nicaragua, Salvador, Costa Rica and Panama to Colombia, Venezuela, the Guianas, Brazil, western Ecuador, western, central, and southeastern Peru to Bolivia (Santa Cruz de la Sierra), northwestern Argentina (Embarcación and Tucumán), Paraguay (Fort Wheeler) and southeastern Brazil (São Paulo).

KEY TO THE SPECIES AND SUBSPECIES OF CHONDROHIERAX

a. Upper mandible pale yellowish white, inclining to bluish horn at the base; feathers of upper parts with concealed white bars on their bases (Cuba) ..... *C. wilsonii*

aa. Upper mandible black; no concealed white bars on the feathers of the upper parts.

b. Size larger; wing 265–301 mm., in males; 268–321 mm. in females.

c. Bill smaller; culmen from cere less than 45 mm.

d. Plumage gray or dark gray, barred beneath with gray or dark gray and white.

e. Ground color of under parts dark blackish plumbeous, white bars wide (about 5 mm.).....*C. u. aquilonis* ad. ♂

ee. Ground color of under parts paler, deep plumbeous; white bars narrow (1.5–3 mm.).....*C. u. uncinatus* ad. ♂

dd. Plumage dark brown or blackish brown above, barred beneath with brown on white ground color or almost unbarred white.

e. Under parts heavily barred.....*C. u. uncinatus* ad. ♀
C. u. aquilonis ad. ♀

ee. Under parts nearly unbarred white.....*C. u. uncinatus* juv.
C. u. aquilonis juv.

cc. Bill very large, culmen 50 mm.....*C. u. immanis* ad. ♀

bb. Size smaller; wing 250 mm., in male; 262–266 mm.
In females (Grenada).....*C. u. mirus.*

I am much indebted to Mr. W. W. Bowen for assistance in compiling measurements and in working out the plumages of these birds. Dr. J. Van Tyne and Mr. L. Griscom also aided by sending notes and opinions about plumages and variations.

MALACOLOGY.—*New Philippine land shells of the genus* Obba.[1]

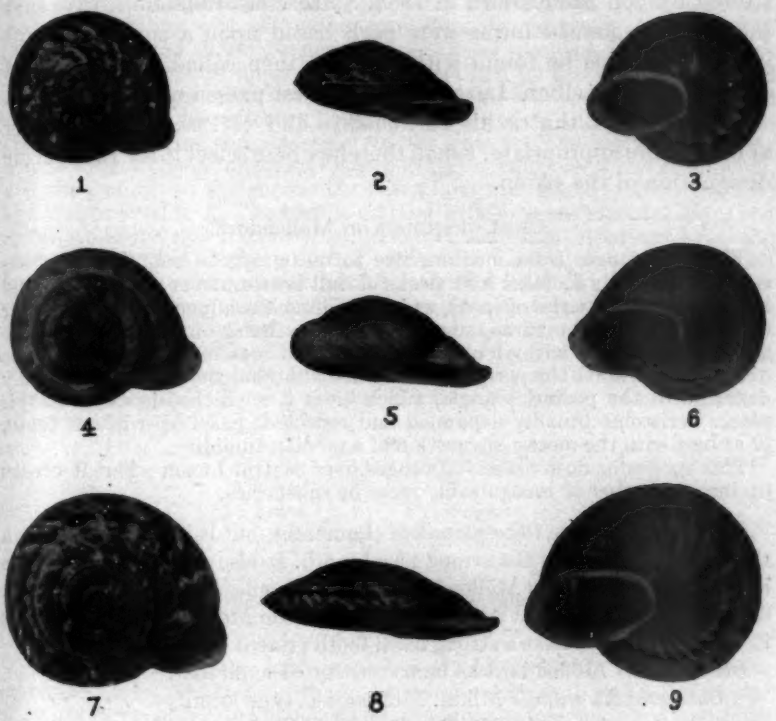
PAUL BARTSCH, U. S. National Museum.

A sending of Obbas to the U. S. National Museum for determination by Mr. Walter F. Webb of Rochester, New York, has brought to light a number of new races, which are here described.

The mass of Philippine material before me belonging to the genus *Obba*, makes it possible to regroup some of the named forms in a more natural arrangement. Mr. Webb's recent sending makes it necessary to give consideration to the mollusks which were described by von Möllendorff (Nachrichtsblatt der Deutschen Malakozoologischen Gesellschaft **20**: 87–88) as

Obbina lasallei Eydoux
Obbina lasallei forma *subcarinata* Mlldff.
Obbina lasallei forma *subcostata* Mlldff.
Obbina lasallei var. *obscura* Mlldff.

[1] Published by permission of the Secretary of the Smithsonian Institution. Received April 6, 1934.



Figs. 1–3.—*Obba listeri cabrasensis.*
Figs. 4–6.—*Obba grandis marivelesensis.*
Figs. 7–9.—*Obba listeri mayae.*

Obbina lasallei var. *grandis* Mlldff.

Also those treated by him in 1898 in the Abhandlungen der Naturforschenden Gesellschaft, Görlitz, 22: 82–85. Here he renames the shell he described as *Obbina lasallei* above, *Obbina lasallei pallida*, and describes:

Obbina planulata subglobosa Mlldff.
Obbina planulata edentula Mlldff.
Obina planulata subangulata Mlldff.
Obbina planulata depressa Mlldff.

Obba lasallei Eydoux typifies an entirely distinct group of forms whose conspicuous colored banding at once removes them from the present complex, which will have to carry one of the four names be-

stowed by von Möllendorff in 1888. Since von Möllendorff says that the first two named forms were each based upon a single aberrant individual which he found with what he then called *Obbina lasallei* Eydoux at Montalban, Luzon, these are best passed over.

Of the others, that is his var. *obscura* and var. *grandis*, the latter appears more appropriate. I shall therefore here select it for the specific designation of the group.

OBBA GRANDIS Von Möllendorff

The shell ranges from medium size to quite large. Ground color flesh-colored, variously mottled with flecks of dull brown, never actually spirally banded, though a series of spots, which are almost confluent a little posterior to the middle of the turns, suggests a narrow band on the upper surface of the whorls. Base with an obscure interrupted zone of dull brown at some distance anterior to the periphery. The last whorl has the outer lip decidedly deflected at the posterior angle, which gives it a pinched-in effect at this place. Peristome broadly expanded and reflected; basal lip without tooth, or at best with the merest suggestion of a median tumidity.

This species as now conceived ranges over central Luzon where it breaks up into a number of recognizable races or subspecies.

It resembles in size *Obba planulata* (Lamarck), but is less depressed than that species and lacks the strong basal tooth. It also suggests some of the races of *Obba sarcochroa* Möllendorff, but the absence of basal tooth at once distinguishes it from that species. *Obba marmorata* Möllendorff also suggests it, but here, too, we have a strong basal tooth present.

Obba grandis Möllendorff as here constituted embraces:

Obba grandis grandis Mlldff. Montalban (type locality).
Obba grandis grandis forma *subcarinata* Mlldff. Montalban.
Obba grandis grandis forma *subcostata* Mlldff. Montalban.
Obba grandis obscura Mlldff. Balacbac.
Obba grandis depressa Mlldff. Morong.
Obba grandis edentula Mlldff. Morong.
Obba grandis subglobosa Mlldff. Sibul.
Obba grandis subangulata Mlldff. Zambales.
Obba grandis marivelesensis Bartsch. Mariveles.

Obba Grandis Marivelesensis, new subspecies

Figs. 4–6

Shell of medium size, lenticular, with moderately elevated, well rounded spire. Periphery feebly angulated. Base moderately well rounded and moderately openly umbilicated. Ground color flesh colored, with a pale buff tinge. The upper surface, particularly on the early postnuclear whorls, flecked and mottled with pale chestnut brown. On the early turns these flecks tend to form an interrupted median line and a second interrupted, less conspicuous line a little anterior to the summit and a third immediately above the suture, which is even fainter. The base is almost unicolor, the

color scheme being varied slightly by retractively curved, faintly brownish streaks coinciding with the incremental lines in placement. Aperture buff within; peristome white. Nuclear whorls 2, well rounded, the first smooth excepting incremental lines, and the last marked by incremental lines and fine spiral striations. The postnuclear whorls are well rounded and marked by fairly strong incremental lines, spiral striations and the microscopic crisscross sculpture characteristic for the species. The early postnuclear whorls seem to be more conspicuously keeled than those of the adult shell, and the summit of the succeeding turns falls immediately below the keel and is appressed to it. The base is marked by strong incremental lines, fine spiral striations and microscopic, crisscross sculpture. Aperture oval, the outer lip deflected at the posterior angle as if pinched down. There is an impressed line at the junction of the outer and basal lip. The basal lip is provided with a very slight swelling in the middle, suggesting in the merest manner a fold. Parietal wall covered with a thin callus.

Type.—U.S.N.M. No. 314046 was collected by Col. Edgar A. Mearns on the beach at Mariveles, Bataan Province, Luzon. It has 5 whorls, and measures: Height 14.7 mm; greater diameter, 29.8 mm; lesser diameter, 23.1 mm.

	Height	Greater Diameter	Lesser Diameter
Average,	13.8 mm.	28.3 mm.	21.98 mm.
Greatest,	15.2 mm.	30.5 mm.	25.1 mm.
Least,	12.3 mm.	25.3 mm.	19.6 mm.

Obba Listeri Mayae, new species

Figs. 7–9

Shell large, lenticular, acutely keeled at the periphery with a narrow umbilicus; color rather dark, the upper surface marbled, with a heavy row of rather large, elongated spots, which are more or less confluent and form a median band between the summit and the periphery. There is a tendency to the formation of two additional bands; one a little anterior to the summit, and the other a little posterior to the periphery. The rest of the upper surface is variously streaked, blotched and spotted with chestnut-brown of a little lighter color than the median band. The under surface is also marked by an almost uninterrupted broad band of brown, which is about as far anterior to the periphery as the median band on the summit is distant from the periphery. The rest of the base posterior to this band is also mottled, but paler than the dorsal surface, while the reach between the umbilicus and the dark band is wax colored, streaked with darker incremental lines. The aperture is buff; the outer lip shows the dark mearkings within. Nuclear whorls 1¾, well rounded, smooth; postnuclear whorls flattened on the upper surface and slightly up-turned toward the periphery. The succeeding turns are appressed to the narrow edged keel but occasionally this projects slightly beyond the summit of the succeeding turn. The postnuclear whorls are marked by retractively curved, slender, incremental lines and numerous, fine spiral threads which give to the surface a finely reticulated pattern. The fine microscopic, crisscross sculpture characteristic for the group is also represented here. In addition to this, the upper surface is marked, particularly on the later whorls, by strong malleations. The under surface is marked by incremental lines, fine wavy spiral striations, which are a

little stronger at the periphery than toward the umbilicus and the crisscross sculpture referred to above. The last part of the last whorl is conspicuously malleated below the periphery. Aperture oval; outer lip reenforced by a rather thick callus, less strong on the parietal wall, provided with a slight notch at the junction of the basal and upper lip and a fairly strong median basal tooth.

Type.—U.S.N.M. No. 314044 and 10 specimens were collected on Guntang Mountain, Lubang Island. The type has 5 whorls, and measures: Height, 10.6 mm; greater diameter, 35.5 mm; lesser diameter, 28.7 mm.

Ten additional specimens, two of which, U.S.N.M. No. 314045, are in the collection of the U. S. National Museum, and the remainder in Mr. Webb's collection, and the type yield the following measurements:

	Height	Greater Diameter	Lesser Diameter
Average,	12.0 mm.	34.5 mm.	27.5 mm.
Greatest,	13.2 mm.	36.3 mm.	28.9 mm.
Least,	10.6 mm.	32.5 mm.	25.8 mm.

This subspecies suggests in general shape the shell that I collected at Port Tilig, Lubang Island, which I named *O. listeri smithi* in Bulletin 100 of the U. S. National Museum, vol. 6, part 8, page 351. It can, however, be distinguished at once from this by the malleations present on the upper and lower surface, which are absent in *smithi*, and by its much less strong spiral striations.

I have named this *mayae* for Mrs. May Webb, the wife of the donor, at his request.

Obba Listeri Cabrasensis, new subspecies

Figs. 1–3

Shell of moderate size, lenticular, rather high, acutely keeled at the periphery with a rather broad umbilicus. The upper surface is of a deep buff-colored ground color, marbled and vermiculated with spots, splotches and dashes of brown, which are largest on the upper surface in a median line where they partly become confluent to form an interrupted broad band. There is an indication of a second band a little anterior to the summit of much lesser dots, and a third immediately above the periphery, which is even more obscure than the one at the summit. On the under surface there is a broad interrupted band of brown almost as far remote from the periphery as the band on the upper surface is from it. In addition to this, there are incremental streaks of pale brown on the buff background on the under surface. The interior of the aperture is pale buff, showing the brown markings within on the outer lip, while the peristome is faintly buff. Nuclear whorls 1.7; the first smooth and the rest marked by faint incremental lines and microscopic spiral striations. The postnuclear whorls are moderately rounded and marked by retractively curved incremental lines and rather strongly incised spiral striations. There are also malleations, which show best on the later turns on the anterior half of the whorls. In addition to this, the entire surface is marked by the fine crisscross sculpture common to the species. Periphery strongly keeled, the succeeding turns abutting the peripheral keel or sometimes passing slightly under it and allowing it to show

as a feeble thread. The under surface is strongly rounded, marked by incremental lines, the spiral striations equaling those on the spire in strength, and the fine crisscross sculpture. The posterior half also shows feeble malleations. Aperture oval; peristome rather broadly expanded and reflected and joined across the parietal wall by a heavy callus, which renders it complete and provided with a rather conspicuous tooth on the middle of the basal lip. There is also a slight notch at the junction of the basal and outer lip.

Type.—U.S.N.M. No. 314042, was collected on Cabras Island. It has 4.8 whorls, and measures: Height, 12 mm; greater diameter, 26.9 mm; lesser diameter, 21.5 mm. This and 99 additional specimens yield the following measurements:

	Height	Greater Diameter	Lesser Diameter
Average,	11.4 mm.	26.8 mm.	21.68 mm.
Greatest,	13.8 mm.	29.8 mm.	24.3 mm.
Least,	10.1 mm.	23.5 mm.	19.0 mm.

This subspecies recalls *Obba listeri recurvata* Möllendorff from the Island of Lubang, differing from it in its slightly more elevated form, more rounded upper surface, the combination of the two giving the shell a more deeply lenticular aspect. The umbilicus here too is wider.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1059TH MEETING

The 1059th meeting was held in the Cosmos Club Auditorium, Saturday, November 11th, 1933, President O. S. Adams presiding.

The program for the evening consisted of four illustrated reports of expeditions from Washington laboratories that participated in the research program of the recent Polar Year.

The reports were presented by E. W. Eickelberg of the U. S. Coast and Geodetic Survey, J. C. Ballard of the U. S. Weather Bureau, K. L. Sherman of the Department of Terrestrial Magnetism, Carnegie Institute of Washington, and by H. B. Maris of the Naval Research Laboratory.

There was a discussion of the reports participated in by Messrs. Heck, Hazard, Gish, Humphreys and Kracek.

1060TH MEETING

The 1060th meeting was held in the Cosmos Club Auditorium, Saturday, November 25th, 1933, President O. S. Adams presiding.

Program: V. L. Chrisler: *Dependence of sound absorption upon the area and distribution of the absorbent material.*—The results of sound absorption measurements were given showing that when one surface of an enclosure is covered with a highly absorbent material it is impossible to have a diffuse distribution of sound energy. As a result the efficiency of the material is lowered. The results were also given on very much smaller areas showing that under these conditions the material may be more efficient than indicated by measurements on 72 sq. ft.

Discussed by Messrs. Hafstad, Hawkesworth, Stimpson, W. P. White, and Wenner.

R. R. Lukens: *Sound ranging as applied to hydrographic survey.*—The application of sound ranging to hydrographic surveying is an outgrowth of the anti-submarine work of the World War. The first experiments by the Coast and Geodetic Survey were made in 1923 with apparatus built by the Bureau of Standards. The system was first used successfully on the Pacific Coast and the apparatus was soon simplified and improved until it became thoroughly practicable. Briefly, sound ranging is accomplished as follows: Hydrophones are planted at known points near the shore and each is connected to a radio station on shore. When the ship wants a position, a T.N.T. bomb is exploded over the side. The explosion is registered on the chronograph carried on board the vessel and the sound waves travel through the water until picked up by the hydrophones near the shore. When the impulse is received through the hydrophone, the radio transmits an instantaneous signal back to the ship and thus the time of the arrival of the sound at each hydrophone is noted on the chronograph tape. By scaling the tape, the time, to one hundredth of a second, required for the sound to travel from the bomb to each shore station, is ascertained. Knowing the velocity of sound in sea water, the distance from each hydrophone is readily computed, and when the arcs are laid down on the survey sheet, the intersection marks the position of the bomb when it exploded. The subject of velocity of sound in sea water is a big one in itself. Wherever possible the velocity is determined experimentally. This can be done when a shore fix is available as the bomb is exploded. Results so far show a remarkable agreement between the experimental velocities and the theoretical velocities using the bottom temperatures. Experiments for obtaining more knowledge of the path of sound through sea water have just been completed on the Pacific Coast, but as yet no definite conclusions have been reached. Sound ranging is capable of great distance. At one time the ship *Guide* on the Pacific Coast got bombs through at a distance of 216 miles. In the work of the past summer, two vessels on the Pacific Coast frequently used stations 100 miles or more distant with excellent results. Sound ranging, or "radio acoustic ranging" as it is known in the Coast and Geodetic Survey, has resulted in greatly increased accuracy in offshore surveys and also in decreased unit costs due to the fact that work can be carried on at night or in thick weather. (Illustrated by demonstration apparatus.)

Discussed by Messrs. Wenner, Heck, Hersey, Hawkesworth and H. L. Curtis.

The following informal communication was presented.

W. Ramberg.—It was desired in connection with the work on propeller vibrations at the Bureau of Standards to find general solutions of the equation of transverse vibration of a slender beam of variable cross section. In searching the literature for such solutions it appeared that the case of a beam formed by the rotation of the curve $y=Ax^n$, $(0<n<1)$, had been worked out in detail by Prof. Nicholson in 1917 (Proc. Roy. Soc. London A. 93:506.–1917) in order to find the nodal positions in such beams as a function of the "shape" exponent n. The purpose of Prof. Nicholson's paper was to check a hypothesis of Prof. Dendy according to which the growths at definite distances from the ends of certain sponge spicules proceed from the nodal points; the nodes, he reasoned, were the only points that were sufficiently quiet to allow these growths in the spicules as they vibrated with

their natural periods under agitation by water currents. This conclusion was checked by Prof. Nicholson's mathematical works.

The biologists interest in the morphology of sponges had thus given impetus to a paper which promises to be of value in the analysis of propeller vibrations.

1061ST MEETING

The 1061st meeting, constituting the 63rd annual meeting, was held in the Cosmos Club Auditorium, Saturday evening, December 9, 1933, President O. S. Adams presiding.

The treasurer reported an income from all sources of $1455.43, and expenditures of $1375.63. He also reported an active membership of 304.

The secretaries reported that the following new members were elected during the year: Irvin Naiman, Louis R. Maxwell, James L. Guion, F. W. Sohon, S. J., N. F. Braaten, B. E. Anderson, George F. Strohaver, S. J., Scott E. Forbush, J. B. Wilke, R. S. Cleveland, R. M. Wick, Charles L. Gordon, Charles T. Allen, Norman Bekkedahl, Paul J. Searles, and Albert E. Coldwell. Alfred H. Hodge elected to membership in 1932 qualified in 1933.

The following deaths were reported: Harlan W. Fisk, Frederic A. Young, and John T. Erwin.

The following officers were declared elected for the year 1934: *President*, H. L. Dryden; *Vice-presidents*, O. H. Gish, and N. H. Heck; *Treasurer*, R. E. Gibson; and for the years 1934 and 1935; *Corresponding Secretary*, F. B. Silbsbee; and *Members-at-large of the General Committee*, W. G. Brombacher, J. H. Taylor.

During the year the third Joseph Henry Lecture in memory of the first President of the Philosophical Society was given by K. T. Compton, President of the Massachusetts Institute of Technology.

At the conclusion of the business meeting, E. O. Hulburt presented a paper on *The polarization of light at sea.*—A polarizing prism properly oriented was found to darken the sea relative to the sky, to reduce the brilliance of the sun path and to render the horizon more distinct. In bright weather it increased the visibility of objects against the sea background. Attaching polarizing prisms to a sextant and to binoculars improved these instruments in certain cases. Measurements of the light of the sea ruffled by a breeze from several hundred yards from the observer out to the horizon several miles away showed that the light was often more, and rarely less, than 2/3 polarized with electric rector mainly horizontal but tilted up under certain conditions, e.g., tilted up 30° for the sun bearing 90° and at 45° altitude. From the observations and theory it came out that the sea light was the light of the sky at about 25° to 35° above the horizon reflected by the sea, the reflecting facets of the sea surface being most frequently at about 15° to the horizontal. The width of the sun path calculated from this was in agreement with the observed width of about 6°, 14° and 18° in moderate weather for the sun at altitudes 10°, 20° and 30° respectively. The foregoing results lead to the explanation of a number of breezy sea reflection phenomena such as: (1) A dark bank of clouds rising up over the horizon does not darken the sea appreciably until it reaches an altitude above 25°; (2) One sees practically no reflection of a black or white ship in the water on a breezy day; (3) The fact that the sea is usually bluer, and of course darker, than horizon sky.

Discussed by Messrs. Bittinger, Humphreys, H. L. Curtis, and Hawkesworth.

1062ND MEETING

The 1062nd meeting was held in the Cosmos Club Auditorium, January 6, 1934, President Dryden presiding.

Program: The address of the retiring president, O. S. Adams, entitled *Flatland; not a romance but a necessary expedient.* This address has since been published in full in this JOURNAL, 24: 201–216. 1934.

F. G. BRICKWEDDE, *Recording Secretary*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

Notes

Helminthological Society.—The Helminthological Society of Washington has initiated the publication of the Proceedings of the Helminthological Society of Washington, Volume 1, No. 1, appearing in March under the editorship of JESSE R. CHRISTIE of the Bureau of Plant Industry. The current number includes the minutes of meetings 157 to 160 together with abstracts of the papers presented at those meetings.

Biological Society.—At the 804th regular and 55th annual meeting of the Biological Society of Washington held on May 5th, 1934, the following officers were elected: *President,* C. E. CHAMBLISS; *Vice-Presidents,* C. W. STILES, H. C. FULLER, T. H. KEARNEY, W. B. BELL; *Recording Secretary,* S. F. BLAKE; *Corresponding Secretary,* JOE S. WADE; *Treasurer,* F. C. LINCOLN; *Members of Council,* W. R. MAXON, A. A. DOOLITTLE, I. N. HOFFMAN, E. P. WALKER, J. E. SHILLINGER.

PERSONAL ITEMS

Detection of incipient weakness of airplane propellers due to fatigue has been facilitated by a new device developed by Drs. HUGH L. DRYDEN and L. B. TUCKERMAN, National Bureau of Standards.

BERTIL RONNMARK, who has been sent to the United States by the Swedish Control Laboratory, Stockholm, to study American governmental methods of drug control, has begun his research in Dr. E. M. NELSON'S vitamin laboratory of the Food and Drug Administration. Sweden has recently enacted a new food and drug law patterned to a certain extent after the late Dr. HARVEY W. WILEY'S pioneer statute.

CHARLES HENRY KUNSMAN, acting chief of the Fertilizer and Fixed Nitrogen Investigations Division of the Bureau of Chemistry and Soils, has been appointed chief.

CHARLES BITTINGER is completing a group of three mural paintings of scenes from the life of Benjamin Franklin for the Franklin Institute, in Philadelphia. These paintings are visible only by fluorescence produced by ultraviolet irradiation; by common daylight they appear merely as blank white wall panels.

At the spring meeting of the Society of Sigma Xi, the following persons were inducted into membership: Dr. L. H. ADAMS, Geophysical Laboratory of the Carnegie Institution of Washington; Dr. A. G. BOVING, Bureau of Entomology; Dr. D. J. PRICE, Bureau of Chemistry and Soils.

FRANÇOIS E. MATTHES, of the United States Geological Survey, has been appointed "titular member," representing the United States, of the Commission Glaciologique of the International Geodetic and Geophysical Union.

Obituary

JOHN MERTON ALDRICH, associate curator of the Division of Insects, U.S. National Museum, died May 27, at Washington, D.C. Dr. ALDRICH was born in Olmsted County, Minnesota, January 28, 1866. He received the B.S. degree from South Dakota State College in 1891, the M.S. from the University of Kansas in 1893, and the Ph.D. in 1906 from Stanford University. He served as assistant zoologist at South Dakota College 1891–92 and from 1893 until 1913 was associated with the University of Idaho, at first in the capacity of professor of zoology and entomologist of the Experiment Station, later as professor of biology in the University. In 1913 he joined the staff of the Bureau of Entomology of the U. S. Department of Agriculture, being stationed at Lafayette, Indiana, where he continued his work with the Diptera. He came to Washington in 1918 and in 1919 was transferred to the U. S. National Museum as associate curator, in charge of the Division of Insects. Included among his many scientific papers there may be mentioned his *Catalogue of the North American Diptera*, published by the Smithsonian Institution in 1905 and an extensive paper on *Sarcophaga and Allies*. His extensive collection of North American flies containing almost 45,000 specimens was donated to the U. S. National Museum in 1923. In addition to the Washington Academy of Sciences, Dr. ALDRICH was a member of the Entomological Society of America (president, 1921), American Association of Economic Entomologists, Entomological Society of Washington (president, 1926), and Sigma Xi.

EDWARD WILLIAM NELSON, former chief of the Bureau of Biological Survey, died May 19, at Washington, D.C. Dr. NELSON was born at Manchester, New Hampshire, on May 8, 1855. He spent his boyhood on his grandfather's farm in New York, and in Chicago. He was graduated from the Cook County Normal School, Chicago, in 1875. He held the honorary degrees of A.M. (Yale, 1920) and Sc.D. (George Washington University, 1920). He joined the Biological Survey of the U.S. Department of Agriculture in 1890, serving in the field at many points and travelling extensively from Alaska to Mexico. During the years 1907–13 he was chief field naturalist of the Survey; 1913–14, in charge of Biological Investigations; 1914–16, assistant chief and 1916–27, chief of the Bureau of Biological Survey. Following his relinquishment of administrative duties he continued with the Survey for two years, retiring in 1929. His scientific studies continued until his death. From his collections hundreds of new species and varieties of birds and mammals have been described by himself and other workers. His published work includes monographs on various groups of mammals and birds. He was also the author of popular books and articles on various

phases of wild life and wild life conservation. In addition to the Washington Academy of Sciences, Dr. NELSON was a member of the American Association for the Advancement of Science, Washington Biological Society (president, 1912), Society of Mammalogists, and a fellow of the Ornithological Union (president, 1908).

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